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MAY 27 1987

New Developments in Biotechnology

2

Background Paper

Public Perceptions of Biotechnology

CONGRESS OF THE UNITED STATES
Office of Technology Assessment
Washington, DC 20510-8025

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Foreword

Throughout its turbulent recent history, the benefits and risks of biotechnology have been scrutinized and discussed by experts in a wide range of fields. Today, biotechnology is perhaps best viewed as a growing cohort of technologies, each with its own scientific benefits and risks, and allied social, economic, legal, and ethical opportunities and controversies. Increasingly during debates on these concerns, the question is asked: "What does the public think?"

In this background paper, OTA reports the results of a nationwide survey of public knowledge and opinion about issues concerning science and technology in general and genetic engineering and biotechnology in particular. The survey, conducted for OTA by Louis Harris & Associates, measures the interest, knowledge, and concern of the public about scientific matters. The willingness of the American people to accept risks in return for benefits of scientific innovation is assessed. The public's reaction to testing genetically engineered organisms in their own community is reported, as is how the American populace feels about human gene therapy. The background paper also reveals the feelings of the American populace toward the future of biotechnology.

This background paper is the second in a series of OTA studies being carried out under an assessment of "New Developments in Biotechnology." Volume one in the series examined commercialization and ownership of human tissues and cells, and forthcoming reports will include evaluations of: U.S. investment in biotechnology; genetically engineered organisms in the environment; tests for human genetic disorders; and the impact of intellectual property law on biotechnology. The assessment was requested by the House Committee on Science, Space, and Technology and the House Committee on Energy and Commerce.

OTA was assisted in preparing this study by an advisory panel and reviewers selected for their expertise and diverse points of view. OTA gratefully acknowledges the contribution of each of these individuals. As with all OTA reports, responsibility for the content of the background paper is OTA's alone. The background paper does not necessarily constitute the consensus or endorsement of the advisory panel or the Technology Assessment Board.

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Chapter 1

Executive Summary

A substantial majority of Americans do not have a sufficient vocabulary or comprehension of concepts to utilize a wide array of scientific communication . . .

—Jon D. Miller
Washington Post, June 2, 1986

The public . . . can assimilate an astonishing amount of technical information if they feel that it's necessary to protect themselves in a dispute.

—Robert C. Forney
Christian Science Monitor, Sept. 26, 1986

Public opinion in this country is everything.

—Abraham Lincoln
Sept. 16, 1859

Chapter 1

Executive Summary

The United States stands at the brink of a new scientific revolution—one based on novel biological techniques—that could significantly alter the lives and futures of many people. While the basic scientific developments that underlie this revolution have occurred already, advances in genetic technology have not yet been applied widely. In the near future, decisions made by the Federal Government will profoundly affect the timing, direction, and limits of this technological revolution—and hence its impact—on the American public. Because government represents all of the public, it cannot ignore the concerns and preferences—no matter the extent of the misconceptions or how transitory the opinions might be—of any portion. It is important for policymakers to know not only what public opinion is, but also on what it is based. But what are the public's perceptions on biotechnology and genetic engineering?

As part of the assessment, "New Developments in Biotechnology," the Office of Technology Assessment commissioned a nationwide survey to answer this question. Conducted by Louis Harris & Associates between October 30 and November 17, 1986, among a national probability sample of 1,273 American adults,[1] this survey gathered information about public knowledge and opinion on science and technology issues in general, and genetic engineering and biotechnology in particular. This background paper presents the data obtained from that survey. It describes **perceptions and beliefs of American adults measured over a 19-day period—public consensus could shift if a cataclysmic event were to occur.**

The survey found widespread interest and concern about scientific and technological issues among the American people. Only about one in six Americans (16 percent) rates his or her basic understanding of science and technology as "very good," and nearly a quarter (23 percent) say that they are "very interested" in scientific and technological matters. And, nearly a third (32 percent) say that they are "very concerned" about government policy concerning science and technology. In all, **nearly half (47 percent) of the adult population of the United States describe themselves as very interested, very concerned, or very knowledgeable about science and technology. OTA defines this population as the science observant public.** Three of ten Americans say they discuss issues related to science and technology at least weekly.

A large majority of the American public (80 percent) says it expects developments in science and technology in the next 20 years to benefit them and their families. At the same time, there is widespread expectation (71 percent) that developments in science and technology will pose at least some risks to them and their families. However, **when faced with the fundamental choice between the risks and benefits to society from continued technological and scientific innovation, a majority of the public (62 percent) feels that the benefits outweigh the risks. In contrast, 28 percent of the public feel that the risks outweigh the benefits.** Neither age, education, nor science observance substantially affects concern about risks of scientific development.

The basic interest in science and technology among the American people carries over to issues of biotechnology and genetic engineering. Two-thirds of the public (66 percent) feel that they understand the meaning of genetic engineering. More than a third (35 percent) say that they have heard or read a fair amount about genetic engineering, yet **only one in five Americans (19 percent) say they have heard about any potential dangers of genetically engineered products. A larger segment of the public (52 percent) believes that genetically engineered products are at least somewhat likely to represent a serious danger to people or the environment.** Nonetheless, a two-thirds majority of the public (66 percent) says it thinks that genetic engineering will make life better for all people.

When all other factors are equal, the public says it is more favorably disposed toward genetic alteration of plants, animals, and bacteria than manipulation of human cells. Approximately one-fourth (24 percent) of the population who have heard about genetic manipulation of DNA to create hybrid plants and animals feel it is morally wrong. Furthermore, 26 percent of the public who are aware of the classic biological techniques of cross-fertilization and crossbreeding also believe that these techniques are morally wrong. This belief opposing any form of biological manipulation, including those in use for thousands of years, is partially a function of religious background. It also reflects a belief that humans should not meddle with nature—a sentiment strongly held by a quarter (26 percent) of the American public.

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[1] Individuals age 18 and older.

Some individuals expressed concern about potential risks of environmental applications of genetically engineered products, as well as the moral status of such products. When queried about specific consequences, a majority of the public believes that it is at least somewhat likely that genetically engineered products could create antibiotic-resistant diseases (61 percent), produce birth defects in humans (57 percent), create herbicide-resistant weeds (56 percent), or endanger the food supply (52 percent). Fewer than one in five Americans, however, thinks any of these outcomes is very likely.

A majority of the public appears willing to accept relatively high rates of risks to the environment to gain the potential benefits of genetically engineered organisms. Fifty-five percent say they would approve the environmental use of an organism that would significantly increase farm production if the risk of losing some local species of plants or fish were 1 in 1,000. As the rate of risk declines, public approval of environmental use of genetically altered organisms for agriculture increases. **However, despite public willingness to approve environmental use of genetically engineered products at relatively high rates of risk, a majority of the public says it would not approve if the risk were unknown—substantially fewer (45 percent) say they would approve if the risk were "unknown, but very remote" than if the risk were 1 in 1,000.**

Under conditions of no direct risk to humans and very remote risks to the environment, a majority of the public says it would approve the environmental use of genetically altered organisms to produce disease-resistant crops (73 percent), bacteria to clean oilspills (73 percent), frost-resistant crops (70 percent), more effective pesticides (56 percent), and larger game fish (53 percent). This overall approval, however, is qualified. **A large majority of the public (82 percent) favors environmental applications of genetically altered organisms on a small-scale, experimental basis. In fact, 53 percent say they would favor and 14 percent state they would not care if their community were selected as a site to test a genetically altered organism. However, only 42 percent of the public think commercial firms should be permitted to apply genetically altered organisms on a large-scale basis.**

The issue of human cell manipulation is more sensitive than other forms of genetic engineering. While a majority of the public (52 percent) believes it is not morally wrong to change the genetic makeup of human cells, a significant minority (42 percent) says that it is. When confronted with specific applications of human cell manipulation, however, many Americans relax their position. A large majority of the American public says it approves of scientists changing the makeup of human cells: to stop children from inheriting a usually fatal genetic disease (84 percent); to cure a usually fatal genetic disease (83 percent); to stop children from inheriting a nonfatal birth defect (77 percent); or to reduce the risk of developing a fatal disease later in life (77 percent). In fact, a large majority of Americans (78 percent) says it would be willing to undergo therapy to have genes corrected if tests showed they were likely to get a serious genetic disease later in life. An even larger majority (86 percent) says it would be willing to have their child undergo genetic therapy, if the child had a usually fatal genetic disease.

Much of the public actually supports a type of human gene therapy that scientists are not now advocating. At the present time, all proposals for human gene therapy are restricted to somatic cells—those that affect the characteristics of the patient, but not the patient's ability to pass on such traits to future generations. Yet a majority of the public says it favors the correction of potentially fatal genetic defects in germ line cells (defects that are passed on to future generations,) as well as somatic cells. **A majority of those who feel human gene manipulation in general is morally wrong nonetheless says it would approve its use in specific therapeutic applications.**

Public support for the development and application of biotechnology is neither uniform nor unequivocal. A third of the public believe, to some extent, that it would be better if humans did not know how to genetically alter cells. Nearly a fifth (18 percent) say they would not approve a proposed application for the environmental release of a genetically altered organism even if the environmental risk were only 1 in 1 million. And 11 percent of the public say they would not approve either somatic or germ line manipulation of human cells, even to cure a disease that is usually fatal. The concerns and preferences of these segments of the population must be weighed against the perception of most Americans that genetic engineering will personally benefit them and their families.

A large majority of the American public (82 percent) believes that research in genetic engineering and biotechnology should be continued. Support for this continued research appears in all segments of the population. In fact, continued research into genetic engineering is supported by majorities of those: who believe human cell manipulation is morally wrong (71 percent); who believe that it is likely that genetically engineered products will represent a serious danger (73 percent); and who feel it would be better if humans did not know how to genetically alter cells (63 percent). This public approval for continuing genetic research spills over into widespread support for government funding of biological research. Despite public concerns about a balanced budget, only 10 percent of the American public say that government funding for biological research should be cut. Forty-three percent of the public believe it should remain the same. Four in ten Americans (40 percent) say that government funding for biological research should be increased. Support for government funding for biological research is bipartisan, with 38 percent of Republicans and 45 percent of Democrats favoring increased funding for this research.

In addition to supporting research, the public also sees another important role for government in the development of biotechnology—regulating and assessing potential risks. When asked who should be responsible for deciding whether commercial firms should be permitted to apply genetically altered organisms on a large-scale basis, a plurality felt that a government agency should decide (37 percent). However, the survey also identifies a potential credibility problem in governmental involvement in biotechnology. **The public believes that Federal agencies are distinctly less able than university scientists to assess potential risks. Moreover, in disputes between Federal agencies and environmental groups over risk statements, the majority of the public says it is inclined to believe the environmental groups.**

In summary, most Americans appear to be pragmatists on the issue of genetic engineering. They are concerned about both the morality and the risks of the technology. **The survey finds that while the public expresses concern about genetic engineering in the abstract, it approves nearly every specific environmental or therapeutic application. And, while Americans find the end products of biotechnology attractive, they are sufficiently concerned about potential risks that a majority believes strict regulation is necessary.** Moreover, the majority of Americans believes that a government agency or an external scientific body should be responsible for deciding about environmental use of genetically altered organisms. At the same time, a majority (55 percent) believes that the risks of genetic engineering have been greatly exaggerated, and 58 percent feel that unjustified fears of genetic engineering have seriously impeded the development of valuable new drugs and therapies.

As in other areas of science and technology, people favor the continued development and application of biotechnology and genetic engineering because they believe the benefits will outweigh the risks. And, **while the public expects strict regulation to avoid unnecessary risks, obstruction of technological development is not a popular cause in the United States in the mid-1980s. This survey indicates that a majority of the public believes the expected benefits of science, biotechnology, and genetic engineering are sufficient to outweigh the risks.**

Chapter 2

Introduction

Chapter 2

Introduction

The United States stands at the brink of a new scientific revolution that could change the lives and futures of its citizens as dramatically as did the Industrial Revolution two centuries ago and the computer revolution today. This new revolution is based on advances in molecular biology that permit the identification, alteration, and transfer of genetic materials that control fundamental characteristics of organisms. The ability to manipulate genetic material to achieve specified outcomes in living organisms (and in some cases their offspring) promises major changes in many aspects of modern life.

At one level, this biotechnology revolution has already occurred. The methods in basic research for identifying genetic instructions, altering them, and transferring the revised instructions to a new organism are established and tested. At another level, however, the biotechnology revolution is imminent but not yet a reality. Only a few products made through recombinant DNA technology have reached the marketplace. The first successful human application of genetic manipulation for therapeutic ends (human gene therapy) has yet to occur. Environmental applications of genetically engineered organisms have only begun to enter the field-test phase. Consequently, widespread commercial uses of genetically engineered products that could revolutionize American life have not yet happened.

Decisions made by the Federal Government will affect the timing, direction, and impact of this technological revolution. Several Federal agencies are responsible for regulating the applications of these new biotechniques. The National Institutes of Health and the Food and Drug Administration (FDA) will oversee the approval process for clinical trials of human gene therapy and develop the regulations for subsequent therapeutic applications. FDA also regulates other biological and pharmaceutical products produced by these new technologies. The Environmental Protection Agency has the responsibility for considering the environmental and ecological impacts of the environmental release of genetically altered micro-organisms. The U.S. Department of Agriculture oversees the certification of agricultural products, including those that will be produced by genetic manipulation.

The opinions and perceptions of the U.S. populace towards the variety of uses of biotechnology and genetic engineering are important components in the Federal role of managing these technologies. In order to assess the public's opinions about science and technology in general—and biotechnology and genetic engineering in particular—the Office of Technology Assessment commissioned Louis Harris & Associates to conduct a survey to gauge citizens' responses to a full range of scientific and technological opportunities, limitations, and consequences of recent biological developments. This background paper describes the results from the survey; it does not discuss the policy implications of the data.

After defining the scope of the study, focus group discussions were held with samples of the public on October 8 and October 9, 1986 to investigate what people thought about the issues on OTA's agenda. Based on a review of the available public opinion research in this field and informed by the results of the focus groups, a survey questionnaire was developed. The survey instrument was pretested on October 16, 1986. The pretest identified areas of difficulty for either interviewer or respondent, and the findings were used to modify the questionnaire. Details of survey methodology appear in appendix A, and the final survey instrument is reproduced in appendix B.

The survey was administered to a national cross-sectional sample of the adult population of the United States, in order to permit projections to the total population. The OTA survey of public perceptions of science, genetic engineering, and biotechnology was conducted between October 30 and November 17, 1986. A total of 1,273 telephone interviews was completed. The characteristics of achieved survey samples typically differ from population estimates due to population noncoverage (nontelephone households) and differential response rates. Consequently, the achieved sample was weighted to Census estimates by education, age, sex, and race. **All survey findings are presented as weighted sample estimates. The unweighted sample base is presented in the tables so that the sampling variance for these estimates can be calculated.** This variance depends, in part, on the sample size. For those instances in the survey when results for the total sample (1,273) are reported, the variance is ± 2 to 3 percent.[1]

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[1] For a recent review article on survey accuracy see P.E. Converse and M.W. Traugott, "Assessing the Accuracy of Polls and Surveys," *Science* 234:1094-1098, 1986.

Chapter 3

Science and the Public

Chapter 3

Science and the Public

Studies to assess public opinion on science, technology, and public policy are not new (2,3,4,5,6,7). The National Science Foundation has monitored public opinion toward science on a regular basis since 1972. The Foundation's *Science Indicators* series considers the opinions of the entire adult population in its estimates (4,5,6,7).

Despite differences in conceptual framework, the earlier studies in this area come to the same conclusion: only a small portion of the total electorate is interested in science, technology, and related public policy, and probably an even smaller portion is sufficiently knowledgeable about the science and technology involved in the public policy debate to make fully informed decisions.

Yet, policymakers represent all of the public and cannot ignore the concerns and preferences—no matter the extent of the misconceptions or how transitory the opinions might be—of any portion. Additionally, not only is it important for them to know what public opinion is, but also on what it is based. Because policymakers need to discriminate among the perceptions and opinions of the different sectors of the public, this background paper first considers the pattern of "science understanding" and "science interest" among the U.S. population and then uses these classifications in the subsequent analyses of public opinion.

UNDERSTANDING OF SCIENCE AND TECHNOLOGY

The OTA survey found that 16 percent of Americans rate their basic understanding of science and technology as "very good." A majority (54 percent) rates its understanding as "adequate." And 28 percent of adults say they consider their understanding of science and technology as "poor" (table 1).

There is relatively little difference by age in the distribution of those who feel they have a very good understanding of science and technology. The proportion of those under 35 years old that says it has a very good understanding (17 percent) is essentially the same as the proportion aged 65 and over (16 percent). Hence, there is no evidence of increased science understanding (as measured by self-rating) in younger individuals.

In contrast, there are clear differences in perceived understanding of science based on education. The proportion of adults who rate their science understanding as very good increases from 12 percent of high school graduates, to 18 percent of those with some college, to 29 percent of college graduates. Since educational attainment is inversely related to age (1), it would appear that if education is taken into account, the perceived understanding of science is actually lower in younger individuals.

One striking finding is a decline between 1982 and 1986 in the proportion of the population that rates its science understanding as very good. In an unpublished 1982 survey of the American public using an identical question, the Harris firm found 22 percent of the public reporting a very good understanding. Four years later, this background paper found that the proportion of the people who rated their understanding of science as very good had declined by 6 percentage points to 16 percent (1).

Table 1.—Basic Understanding of Science and Technology

Question (Q3):[a] If you had to rate your own basic understanding of science and technology, would you say it is very good, adequate, or poor?

		Very good	Adequate	Poor	Not sure
Total 1986	**(1,273)[b]**	**16%**	**54%**	**28%**	**1%**
1982[c]	(1,254)	22	53	25	1
Sex:					
Male	(635)	23	57	20	1
Female	(638)	10	52	35	2
Age:					
18 to 34	(546)	17	59	23	<1
35 to 49	(343)	16	54	27	2
50 to 64	(252)	14	46	37	3
65 and over	(127)	16	53	30	1
Education:					
Less than high school	(165)	14	49	34	3
High school graduate	(458)	12	54	33	1
Some college	(300)	18	61	20	1
College graduate	(347)	29	57	14	<1
Race:					
White	(1,096)	15	55	28	1
Black	(140)	23	54	23	<1
Place:					
Central city	(383)	19	57	23	1
SMSA[d] remainder	(583)	16	54	28	1
NonSMSA	(307)	13	52	33	1

[a] The code number of the question in the survey instrument (see app. B.)

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

[c] Unpublished Harris survey.

[d] Standard Metropolitan Statistical Area.

SOURCE: Office of Technology Assessment, 1987.

INTEREST IN SCIENCE AND TECHNOLOGY

Nearly a quarter of the public (23 percent) say they are "very interested" in scientific and technological matters. About half of adult Americans (48 percent) say they are "somewhat interested." The remainder of the public says it is either "rather uninterested" (11 percent) or "not interested at all" (18 percent).

Science interest follows a demographic pattern similar to that of science understanding; both interest in and understanding of science and technology increase with education. The proportion that says it is very interested in scientific and technological matters increases from about 17 percent of those with high school degrees or less, to 28 percent of those with some college, to 40 percent of college graduates (table 2).

At the same time, age appears to make no real difference in science interest: 22 percent of persons 18 to 34, 25 percent of those 35 to 49, 22 percent of those 50 to 64, and 23 percent of persons aged 65 and older report they are very interested in science. Again, given the relationship between age and education this means that, controlling for education, interest in science is lower among the younger age groups.

As in public understanding, public interest in science also declined between 1982 and 1986. In 1982, an unpublished Harris survey found 29 percent of the public said they were very interested in scientific and technological matters (1). Using an identical question 4 years later, this study found that only 23 percent say they are very interested. This difference exceeds the maximum expected sampling variance associated with these samples. Therefore, the observed decline in the public's interest in science between 1982 and 1986 is statistically significant and cannot be explained by sampling error.

Table 2.—Interest in Science and Technology

Question (Q1):[a] How much interest do you have in scientific and technological matters—are you very interested, somewhat interested, rather uninterested, or not interested at all?

		Very interested	Somewhat interested	Rather uninterested	Not interested at all	Not sure
Total 1986	**(1,273)[b]**	**23%**	**48%**	**11%**	**18%**	**1%**
1982[c]	(1,254)	29	58	8	4	<1
Sex:						
Male	(635)	28	47	7	16	1
Female	(638)	18	48	14	19	1
Age:						
18 to 34	(546)	22	50	13	14	<1
35 to 49	(343)	25	50	9	15	1
50 to 64	(252)	22	47	9	20	2
65 and over	(127)	23	38	10	29	—
Education:						
Less than high school	(165)	18	37	13	31	2
High school graduate	(458)	17	50	13	20	1
Some college	(300)	28	57	8	7	<1
College graduate	(347)	40	49	8	4	<1

[a] The code number of the question in the survey instrument (see app. B.)

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

[c] Unpublished Harris survey.

SOURCE: Office of Technology Assessment, 1987.

The proportion of the public reporting that it is very interested in science and technology in this survey (23 percent) is substantially smaller than that classified as very interested in science and technology in a 1985 survey (41 percent) (3). The difference can be explained by differences in wording of the questions between the two surveys. Questions in the earlier survey emphasize interest in new scientific discoveries and new inventions. The 1985 survey also found a 4- to 8-percentage-point decline in science interest between 1983 and 1985—comparable to the 6-percentage-point decline between 1982 and 1986 observed through this survey.

The apparent decline in public interest in science and technology cannot be explained by this single-instance survey. The survey can, however, show in what population segment the decline in interest occurred (1). Analysis of the data reveals no statistically significant decline between 1982 and 1986 in the proportion of college graduates (41 percent to 40 percent) or those with some college (28 percent to 28 percent) that is very interested in scientific and technological matters. Nor is there any significant decline in the proportion of these groups that is somewhat interested (table 3). In contrast, the proportion of those with less than a high school education that is at least somewhat interested dropped from 74 percent in 1982 to 55 percent in 1986. Similarly, the proportion of high school graduates who are at least somewhat interested dropped from 86 percent to 67 percent during the 4-year period examined. Hence, the survey findings document a marked decline in interest in science and technology among those without college education, rather than among all parts of American society. The source of this increased educational segmentation of science interest remains unknown.

SCIENCE EXPOSURE

Previous surveys have proposed the concept of "scientific attentiveness" as a useful approach to analyzing the concerns and preferences of the American people concerning science policy (3). It has been suggested that those who are attentive to science and technology issues are far more likely to have fully formed attitudes in this area (3). A 1985 survey classified science attentives as

Table 3.—Interest in Science and Technology by Education

Question (Q1):[a] How much interest do you have in scientific and technological matters—are you very interested, somewhat interested, rather uninterested, or not interested at all?

		Very interested	Somewhat interested	Rather uninterested	Not interested at all	Not sure
Education:						
Less than high school						
1982[b]	(69)[c]	26%	48%	14%	13%	—
1986	(165)	18	37	13	31	2%
High school graduate						
1982	(582)	24	62	8	5	1
1986	(458)	17	50	13	20	1
Some college						
1982	(294)	28	61	9	1	<1
1986	(300)	28	57	8	7	<1
College graduate						
1982	(306)	41	51	7	1	—
1986	(347)	40	49	8	4	<1

[a] The code number of the question in the survey instrument (see app. B.)

[b] Unpublished Harris survey.

[c] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

having both a very good understanding of science and technology and being very interested in scientific and technological issues. Applying this criterion, the 1985 survey identified only 20 percent of the adult population as scientifically attentive (3). Applying the criterion to somewhat different measures in this survey, only 8 percent of the public would be categorized as science attentive (table 4).

Yet this view of public knowledge and interest in science does not correlate with the public's outward behavior regarding science information. This study documents an active pattern of science information seeking among the public. One-quarter of the public reports reading books or magazines on science and technology daily (6 percent) or weekly (19 percent). More dramatically, 36 percent say they read the science section of the news-

Table 4.—Comparison of Science Interest and Science Understanding

Question (Q1):[a] How much interest do you have in scientific and technological matters—are you very interested, somewhat interested, rather uninterested, or not interested at all?

Question (Q3): If you had to rate your own basic understanding of science and technology, would you say it is very good, adequate, or poor?

	Understanding of science		
	Very good	Adequate	Poor
	(209)[b]	(707)	(316)
Interest in science:			
Very interested	50% [8][c]	23% [13]	5% [1]
Somewhat interested	30 [5]	57 [32]	41 [10]
Rather uninterested	8 [1]	7 [4]	20 [5]
Not interested at all	10 [2]	12 [7]	32 [8]
Not sure	1 [<1]	<1 [<1]	1 [<1]

[a] The code number of the question in the survey instrument (see app. B.)

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

[c] The number in brackets indicates the percentage of the total sample e.g., 50 percent of those who report a very good understanding of science also report they are very interested, and this subpopulation represents 8 percent of the total sample.

SOURCE: Office of Technology Assessment, 1987.

Table 5.—Sources and Frequency of Science Information

Question (F6):[a] How often do you (READ EACH ITEM)—daily, weekly, monthly, occasionally, hardly ever, or never?

	Read books or magazines on science or technology	Read science section of newspaper	Discuss issues related to science
	(1,273)[b]	(1,273)	(1,273)
How often:			
Daily	6%	15%	9%
Weekly	19	21	21
Monthly	15	5	10
Occasionally	35	29	37
Hardly ever/never	18	17	16
Not sure	7	11	6

[a] The code number of the question in the survey instrument (see app. B.)

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

Table 6.—Science and Technology Occupations in Household

Question (F5):[a] Does anyone in your household have a science or technology related job?

		Yes	No
Total	**(1,273)[b]**	**17%**	**82%**
Age:			
18 to 34	(546)	20	79
35 to 49	(343)	22	78
50 to 64	(252)	13	86
65 and over	(127)	8	91
Education:			
Less than high school	(165)	4	95
High school graduate	(458)	13	86
Some college	(300)	26	73
College graduate	(347)	38	62

[a] The code number of the question in the survey instrument (see app. B.)

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

paper either daily (15 percent) or weekly (21 percent) (table 5). Such reports indicate an active interest in science and technology that is far more widespread than suggested by the narrow definition of scientific attentiveness. Frequent reading of books, magazines, and newspaper articles on science and technology is probably an important measure of science interest. The ability of the public to explain scientific terminology is discussed in chapter 6.

Reading about science is a passive activity. However, the survey finds that a substantial portion of the public also states that it regularly engages in active discussions of scientific issues. In fact, 3 out of 10 adult Americans say they discuss issues related to science either daily (9 percent) or weekly (21 percent). Opinions about science are probably formed through such active discussions of issues.

In addition to reading or discussing science issues, Americans are exposed to science and technology in other ways. Seventeen percent of the public report they have (or someone else in the household has) a science- or technology-related job. This self-reported prevalence of science-related jobs in the household varies from 4 percent of those with less than high school degrees to 38 percent of college graduates (table 6).

The rarest form of science exposure is actual involvement in scientific groups and organizations. Nonetheless, more than 1 in 20 Americans (6 percent) reports activity in scientific groups or organizations. Among college graduates, nearly one in five (19 percent) reports being active in scientific groups or organizations (table 7). Thus, when passive activity, active discussion, and actual involvement in science organizations are considered together, the OTA survey suggests fairly widespread interest, observance of, and involvement in science and technology in America.

As one might expect, there is a strong relationship between exposure to science and understanding of science issues. A majority of those who feel they have a very good understanding of science

Table 7.—Participation in Scientific Groups or Organizations

Question (F7a):[a] Are you active in any scientific groups or organizations?

		Yes	No
Total	**(1,273)[b]**	**6%**	**94%**
Sex:			
Male	(635)	8	92
Female	(638)	4	96
Age:			
18 to 34	(546)	6	94
35 to 49	(343)	9	91
50 to 64	(252)	5	94
65 and over	(127)	2	98
Education:			
Less than high school	(165)	1	98
High school graduate	(458)	3	97
Some college	(300)	7	93
College graduate	(347)	19	81
Science orientation:			
Observant	(626)	11	89
Nonobservant	(647)	2	98
Science understanding:			
Very good	(236)	18	82
Adequate	(707)	5	95
Poor	(316)	1	99

[a] The code number of the question in the survey instrument (see app. B.)

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

says it reads the science section of the newspaper at least weekly (55 percent) and discusses issues related to science at least weekly (51 percent). These individuals are also likely to report that they read books and magazines about science or technology at least weekly (43 percent) and have someone in the household with a science- or technology-related occupation (33 percent) (table 8). **However, public interest and exposure to science issues are not limited to people who are science knowledgeable. Two of five adults who feel they have only an adequate understanding of science (40 percent) and one in five who feel that their science understanding is poor (20 percent), say they read the science section of newspapers at least weekly.** Furthermore, it is not unusual for persons who say their science understanding is adequate (31 percent) or poor (18 percent) to report frequent discussions of issues related to science. **Interest in science issues in the United States is not restricted to the experts**, although it is more common among the better educated.

Table 8.—Comparison of Science Understanding and Science Contact

	Understanding of science		
	Very good	Adequate	Poor
	(209)[a]	(707)	(316)
Active in science organization	18%	5%	1%
Science occupation in household	33	18	8
Read books or magazines on science or technology: daily or weekly	43	26	11
Discuss issues related to science: daily or weekly	51	31	18
Read science section of newspapers: daily or weekly	55	40	20

[a] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

CONCERN ABOUT SCIENCE POLICY

The need to estimate the number of Americans who actually care about science policy underlies past attempts to define science attentiveness. In this survey, respondents were asked how concerned they are with science policy. **Nearly one-third of the American public (32 percent) report that they are "very concerned" about science policy. Most of the remainder of those questioned (50 percent) say they are "somewhat concerned."** Only 18 percent state they are "not very concerned" (11 percent) or "not at all concerned" (7 percent) about science policy (table 9).

The proportion of persons who say they are very concerned about science policy increases with age. Among those who are 18 to 34 years old, only 26 percent say they are very concerned with science policy. This very concerned group increases to 30 percent of those 35 to 49, 34 percent of those 50 to 64, and 44 percent of those 65 and over.

The proportion of the public that reports it is very concerned about science policy does not increase directly with education. However, college graduates are more likely than other groups to say they are very concerned with science policy (44 percent).

Concern about science policy increases with science understanding. Nearly half of those who believe they have a very good understanding of science (46 percent) also state they are very concerned with science policy, compared to a third of those who report an adequate understanding (34 percent) and a fifth of those who say they have a poor understanding (19 percent). It is noteworthy, however, that **concern about science policy is found across all demographic subpopulations.**

Table 9.—Concern About Science Policy

Question (Q2):[a] How concerned are you about government policy concerning science and technology—are you very concerned, somewhat concerned, not very concerned, or not concerned at all?

		Very concerned	Somewhat concerned	Not very concerned	Not concerned at all	Not sure
Total 1986	**(1,273)[b]**	**32%**	**50%**	**11%**	**7%**	**1%**
Sex:						
Male	(635)	35	49	9	6	<1
Female	(638)	29	50	13	7	1
Age:						
18 to 34	(546)	26	52	13	9	—
35 to 49	(343)	30	58	8	4	<1
50 to 64	(252)	34	46	11	6	2
65 and over	(127)	44	36	12	6	2
Education:						
Less than high school	(165)	32	42	17	8	1
High school graduate	(458)	24	56	11	9	1
Some college	(300)	36	53	8	3	1
College graduate	(347)	44	45	8	2	<1
Science understanding:						
Very good	(236)	46	46	4	3	1
Adequate	(707)	34	52	10	4	1
Poor	(316)	19	50	18	13	<1

[a] The code number of the question in the survey instrument (see app. B.)

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

SCIENCE OBSERVANCE

As mentioned earlier, surveys in the past have narrowly defined a science attentive public as only those individuals who have a very good understanding of science and who are very interested in science (3). **The OTA survey reveals, however, that the people who say they are very interested in science are not always those who say they are very knowledgeable. Moreover, those who say they are very concerned about science policy are not always either very interested in science or very knowledgeable about science.**

Given the differences in understanding, interest, and concern among the population, **OTA defines the "science observant" public as those persons who say they have a very good understanding of science, or are very interested in science and technology matters, or are very concerned with science policy.** A person holding any one of these positions is probably more likely to become aware of current science policy issues and debates.

Using this approach, approximately half the adult population of the United States (47 percent) can be classified as observant of science issues (table 10). Men (54 percent) are more likely than women (41 percent) to be observant of science issues. The prevalence of scientific observance increases with age from 43 percent among those 18 to 34 years old to 57 percent of those 65 and older. Although there is not a consistent relationship between education and science observance,

Table 10.—Profile of Population Classified as "Science Observant"

		Observant	Nonobservant
Total	**(1,273)[a]**	**47%**	**53%**
Sex:			
Male	(635)	54	46
Female	(638)	41	59
Age:			
18 to 34	(546)	43	57
35 to 49	(343)	45	55
50 to 64	(252)	50	50
65 and over	(127)	57	43
Education:			
Less than high school	(165)	47	53
High school graduate	(458)	39	61
Some college	(300)	51	49
College graduate	(347)	62	38
Race:			
White	(1,096)	46	54
Black	(140)	50	50
Science understanding:			
Very good	(236)	100	
Adequate	(707)	44	56
Poor	(316)	23	77
Science interest:			
Very interested	(327)	100	
Somewhat interested	(638)	38	62
Rather uninterested	(133)	26	74
Not interested at all	(168)	20	80
Concern about science:			
Very concerned	(419)	100	
Somewhat concerned	(650)	24	76
Not very concerned	(126)	13	87
Not at all concerned	(69)	20	80

[a] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

college graduates are more likely than other groups to be observers of science (62 percent).

The survey finds relatively little evidence that the science observants are substantially more likely to become engaged in political advocacy. The incidence of science observants among those who say they have voted in recent congressional elections (50 percent), local elections (52 percent), campaigned for a candidate (52 percent), or written to a public official (55 percent) is not much higher than the norm. Moreover, these somewhat higher rates of political activity among science observants can be accounted for as a function of age, sex, and educational differences (1).

Finally, science observance is apparently nonpartisan. The proportion of Republicans who are scientifically observant is 47 percent compared to 48 percent of Democrats. Among those who describe their political philosophy as conservative and among liberals, an identical 48 percent are scientifically observant (table 11).

Table 11.—Science Observance and Politics

		Observant	Nonobservant
Total	**(1,273)[a]**	**47%**	**53%**
Political philosophy:			
Conservative	(478)	48	52
Middle of the road	(511)	45	55
Liberal	(233)	48	52
Party affiliation:			
Republican	(435)	47	53
Independent	(334)	44	56
Democrat	(441)	48	52
Political activities:			
Written a letter to official	(432)	55	45
Contributed to political campaign	(494)	58	42
Campaigned for political candidate	(153)	52	48
Voted on local issue	(746)	52	48
Voted in congressional election	(935)	50	50

[a] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

Chapter 4

Benefits and Risks From Science

Chapter 4

Benefits and Risks From Science

Public perceptions of the risks and benefits of genetic engineering and biotechnology are probably developed within a more general context of public beliefs about science. What are the perceptions of the public concerning the risk-benefit equation for the broad issues of science and technology?

The OTA survey found that the American people say they are basically optimistic about scientific progress and technological development. **A large majority of the public expects developments in science and technology in the next 20 years to benefit them and their families. Although the public says it expects some risks from scientific and technological developments, the large majority believes that the benefits to society from technological innovation will outweigh the risks. The risks of scientific and technological development are frequently viewed as overstated and overblown.**

Despite the basically positive orientation of the public toward scientific growth and technological progress, there is evidence of growing public support for increased control over technological development. Although a plurality still favors maintaining the current degree of regulatory control over science and technology, the proportion that says it favors increased control has risen from 31 to 43 percent over the past decade. There is a consensus in favor of technological growth, but control over perceived risks is increasingly important to the public.

BENEFITS FROM SCIENCE

Self-interest could be the cornerstone of American perceptions of science. The OTA survey clearly demonstrates that most Americans believe they and their families will personally benefit from developments in science and technology over the next 20 years. The survey found that 41 percent of Americans say they expect "a lot" of benefit for themselves and their families from developments in science and technology over the next two decades, and a nearly equal number (39 percent) say they expect "some benefit" to be gained from scientific developments. Fewer than one in five Americans reports expecting "little" (14 percent) or "no" (5 percent) personal benefit from science and technology (table 12).

Public expectations concerning the benefits of science increase with education. Only 28 percent of those without a high school degree say they expect a lot of benefit from science and technology. In contrast, 57 percent of college graduates say they expect developments in science and technology to bring a lot of benefit.

The perceived benefits of scientific developments also vary with age. Nearly half (48 percent) of those who are 35 to 49 years old say they expect a lot of benefit from developments in the next 20 years. Younger adults—18 to 34—believe themselves somewhat less likely to benefit a lot from scientific and technological developments (42 percent). Those 50 to 64 years old (34 percent) and 65 and over (33 percent) say they are less likely to anticipate a lot of personal benefit from scientific and technological advances.

Despite variations associated with age or education, a majority of all demographic subgroups investigated says it expects at least some benefit to themselves and their families from future developments in science and technology. And, importantly, Americans say they expect personal benefits from scientific growth to continue for the near future.

Table 12.—Amount of Benefit From Science

Question (Q5):[a] How much benefit do you expect you and your family to get from developments in science and technology in the next 20 years—a lot of benefit, some benefit, little benefit, or no benefit?

		A lot	Some	Little	None	Not sure
Total	**(1,273)[b]**	**41%**	**39%**	**14%**	**5%**	**2%**
Age:						
18 to 34	(546)	42	40	14	3	1
35 to 49	(343)	48	38	12	2	1
50 to 64	(252)	34	37	15	9	5
65 and over	(127)	33	37	15	11	3
Education:						
Less than high school	(165)	28	41	16	12	3
High school graduate	(458)	39	39	17	4	1
Some college	(300)	45	40	10	3	2
College graduate	(347)	57	35	6	1	1
Science understanding:						
Very good	(236)	56	31	7	3	3
Adequate	(707)	41	40	14	4	1
Poor	(316)	31	40	17	9	3
Science orientation:						
Observant	(626)	51	33	10	4	3
Nonobservant	(647)	32	44	17	6	1
Party affiliation:						
Republican	(435)	45	40	11	3	1
Independent	(334)	40	39	14	5	1
Democrat	(441)	38	37	16	7	3

[a] The code number of the question in the survey instrument (see app. B.)

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

RISKS FROM SCIENCE

Counterpoint to the benefits of scientific growth are the potential risks new technology could entail. Survey respondents, therefore, were asked the degree of risk to themselves and their families that developments in science and technology might cause over the next 20 years. Slightly more than a fifth (22 percent) feel that advances in science and technology will cause "a lot" of risk to them and their families. Nearly half (49 percent) believe that these developments will pose "some" risk. The rest of the public says it sees "little" (20 percent) or "no" (7 percent) risk from scientific or technological advances during the next two decades (table 13).

A substantial difference exists in the perception of the likelihood of risks and benefits from scientific and technological developments. Nearly twice as many people (41 percent) expect a lot of benefits as expect a lot of risk (22 percent). But, the perceived cost-benefit ratio of such development varies across subgroups of the population. Among the college educated, for example, 57 percent say they expect a lot of benefit, while only 18 percent state they expect a lot of risk. In contrast, for those without a high school diploma, there is little difference between the proportion that says it expects a lot of benefit from scientific and technological developments (28 percent) and the group that says it expects a lot of risk (24 percent).

The difference in cost-benefit of scientific and technological development is primarily on the benefit side of the equation. Subgroups differ little in their estimate of the risk. There is no measurable difference in the proportion that believes there is a lot of risk from scientific and technological developments among those 18 to 34 years old (21 percent), those 35 to 49 (20 percent), and those 50 to 64 years old (22 percent)—although those 65 and over are slightly more likely to state they expect a lot of risk (27 percent).

Table 13.—Amount of Risk From Science

Question (Q6):[a] How much risk to you and your family do you think developments in science and technology will cause in the next 20 years—a lot of risk, some risk, little risk, or no risk?

		A lot	Some	Little	None	Not sure
Total	**(1,273)[b]**	**22%**	**49%**	**20%**	**7%**	**2%**
Age:						
18 to 34	(546)	21	50	22	6	1
35 to 49	(343)	20	53	18	7	2
50 to 64	(252)	22	44	21	11	2
65 and over	(127)	27	45	15	8	5
Education:						
Less than high school	(165)	24	40	24	10	3
High school graduate	(458)	22	52	17	7	1
Some college	(300)	23	49	21	5	2
College graduate	(347)	18	53	20	7	2
Science understanding:						
Very good	(236)	22	42	23	10	3
Adequate	(707)	22	50	19	7	1
Poor	(316)	22	49	19	6	4
Science orientation:						
Observant	(626)	23	46	20	9	2
Nonobservant	(647)	21	51	20	6	2
Party affiliation:						
Republican	(435)	17	51	23	7	2
Independent	(334)	23	51	16	8	2
Democrat	(441)	24	46	20	7	2

[a] The code number of the question in the survey instrument (see app. B.)

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

Education also does not influence the expectation that a lot of risk will be caused by scientific and technological innovation. The proportion that reports it expects a lot of risk is about the same among those with less than a high school diploma (24 percent), high school graduates (22 percent), and those with some college (23 percent). Those with college degrees are only slightly less likely to say they expect a lot of risk (18 percent).

Finally, there is no difference in the proportion that says it expects a lot of risk among those who feel that their understanding of science is very good (22 percent), adequate (22 percent), or poor (22 percent). Similarly, the science observants (23 percent) and the science nonobservants (21 percent) are about equally likely to say they expect a lot of risk from scientific and technological developments.

Thus, concern about the personal risks of scientific and technological development appears to be uniform across most subgroups of the general American populace. Neither age, education, nor science observance substantially affects concern about risks of scientific development. This survey does not pinpoint the source of this background fear of technological risks.

RISKS V. BENEFITS

A comparison of the public perceptions of benefits and risks from science suggests that the public sees more benefit than risk. When the amount of personal benefit from scientific and technological developments is cross-tabulated with the amount of risk expected, a plurality (43 percent) reports more benefits than risks (e.g., a lot of benefit and some risk). Another 30 percent say they expect the same general level of risk and benefit from scientific and technological developments (e.g., some benefit and some risk), and 21 percent say they expect more risk than benefit from sci-

Table 14.—Comparison of Amounts of Risk and Amounts of Benefit[a]

Question (Q5):[b] How much benefit do you expect you and your family to get from developments in science and technology in the next 20 years—a lot of benefit, some benefit, little benefit, or no benefit?

Question (Q6): How much risk to you and your family do you think developments in science and technology will cause in the next 20 years—a lot of risk, some risk, little risk, or no risk?

	A lot of risk	Some risk	Little risk	No risk	Not sure
A lot of benefit	7%	22%	7%	3%	1%
Some benefit	8	19	8	2	1
Little benefit	4	5	3	1	<1
No benefit	2	1	1	1	<1
Not sure	1	<1	<1	<1	<1

[a] Percentages are presented as weighted sample estimates. The unweighted base from which the sampling variance can be calculated is 1,273.

[b] The code number of the question in the survey instrument (see app. B.)

SOURCE: Office of Technology Assessment, 1987.

ence and technology (e.g., some benefit and a lot of risk) (table 14).

These general categories of risk and benefit, however, mask how widespread the belief is that benefits exceed risks. To measure this basic orientation toward risks or benefits, the surveyed Americans were asked:

> In your opinion, over the next 20 years will the benefits to society resulting from continued technological and scientific innovation outweigh the related risks to society or not?

Faced with this fundamental choice, a majority of the American public (62 percent) says it believes that the benefits of continued technological and scientific innovation "will outweigh the related risks." A minority (28 percent) of the public feels the "benefits will not outweigh the risks." Smaller segments of the public say they are "not sure" (7 percent) or say it "depends" (4 percent) (table 15).

Education appears to be the central influence in an individual's assessment of the cost-benefit outcome of scientific innovation. Half (50 percent) of those without a high school degree believe that the benefits will outweigh the risks. In contrast, three-quarters (74 percent) of college graduates surveyed by OTA believe the benefits will outweigh the risks.

Age also has an effect on the perceived balance of risks and benefits of scientific and technological development. Individuals in the younger age bracket seem more concerned about the risks of innovation. Although only a fifth (20 percent) of those aged 65 and older believe the benefit will not outweigh the risks of scientific and technological development, this perception is held by nearly a third (32 percent) of those 18 to 34 years old.

PUBLIC OPTIMISM

While the OTA survey documented a decline in public interest in science, it found no measurable decline in public optimism toward science during the 1980s. In 1980, 58 percent of the American public felt the benefits of scientific developments would outweigh the risks (1). The OTA survey found that an even larger proportion of the public (62 percent) feels that the benefits of scientific innovation outweigh the risks.

The stability in public optimism about science is curious, given the 6-percentage-point decline between 1982 and 1986 in the numbers of people who say they are very interested in science, and the 10-percentage-point decline in those who are somewhat interested (58 to 48 percent). Since public confidence that the benefits of scientific innovation will outweigh the risks has increased, the waning interest in science and technology

Table 15.—Weighing the Benefits of Science v. Risks

Question (Q7):[a] In your opinion, over the next 20 years will the benefits to society resulting from continued technological and scientific innovation outweigh the related risks to society, or not?

		Benefits will outweigh risks	Benefits will not outweigh risks	Depends	Not sure
Total 1986	**(1,273)[b]**	**62%**	**28%**	**4%**	**7%**
1980[c]	(1,487)	58	25	3	14
Age:					
18 to 34	(546)	60	32	2	5
35 to 49	(343)	65	25	4	5
50 to 64	(252)	62	27	4	6
65 and over	(127)	60	20	7	12
Education:					
Less than high school	(165)	50	37	4	9
High school graduate	(458)	61	30	2	6
Some college	(300)	69	20	5	6
College graduate	(347)	74	16	6	4
Science understanding:					
Very good	(236)	66	27	3	4
Adequate	(707)	64	26	4	6
Poor	(316)	56	31	4	9
Science orientation:					
Observant	(626)	68	22	4	5
Nonobservant	(647)	56	33	3	8
Voters:	(935)	65	24	5	6

[a] The code number of the question in the survey instrument (see app. B.)

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

[c] Louis Harris & Associates, *Risk in a Complex Society*, 1980.

SOURCE: Office of Technology Assessment, 1987.

among the less educated subgroups is probably not a result of fear. Likewise, the decreased interest cannot be attributed to declining confidence in science.

What is striking about the survey findings is the resilience of American confidence in science and technology in the face of major setbacks in 1986.

- In January 1986, the space shuttle Challenger exploded, followed by a series of failed rocket launches.
- Only a year after the disastrous chemical release in Bhopal, India, a major chemical spill in Europe poisoned the Rhine River in 1986.
- Less than a decade after the nuclear accident at the Three Mile Island nuclear plant in the United States, much of Europe was affected by the release of radiation from the Soviet nuclear plant catastrophe at Chernobyl.

Yet, in the face of one of the most disastrous years in memory for high technology, the OTA survey found that a great majority of the public continues to believe that the benefits of scientific development outweigh the risks, and that confidence in science and technology appears to have increased, not decreased.

BELIEFS ABOUT TECHNOLOGICAL RISK

The public expresses mixed opinions about the risks of scientific and technological development. On the one hand, the public says it is genuinely concerned about the unforeseen consequences of modern technology. A sizable majority (61 percent) says it agrees with the proposition that: "Society has only perceived the tip of the iceberg with regard to the risks associated with modern technology." A majority of college graduates (54 percent) also states its agreement.

On the other hand, much of the public also believes that the problems of technological development may have been blown out of proportion. A majority of the public (54 percent) agrees with the proposition: "The risks associated with advanced technology have been exaggerated." An even larger majority (59 percent) reports it takes the position: "Most of the risks of new technology that people worry about never really happen." Individuals in all educational categories share this sense that the true risks of technological development have been overblown (table 16).

Table 16.—Beliefs About the Risks of Science

Question (Q8a-d):[a] Thinking about society as a whole, please tell me whether you tend to agree or disagree with each of the following statements. (READ EACH STATEMENT)

		Education			
	Total	Less than high school	High school graduate	Some college	College graduate
	(1,273)[b]	(165)	(458)	(300)	(347)
a. Unless technological development is restrained, the overall safety of our society will be jeopardized significantly in the next 20 years.					
Agree	42%	50%	45%	42%	23%
Disagree	54	46	50	55	74
b. The risks associated with advanced technology have been exaggerated.					
Agree	54	58	52	50	53
Disagree	43	38	44	46	43
c. Society has only perceived the tip of the iceberg with regard to the risks associated with modern technology.					
Agree	61	65	62	62	54
Disagree	33	28	33	34	42
d. Most of the risks of new technology that people worry about never happen.					
Agree	59	59	59	57	63
Disagree	37	36	38	40	33

[a] The code number of the question in the survey instrument (see app. B.)

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

GROWTH AND CONTROL OF SCIENCE AND TECHNOLOGY

In general, Americans report they are comfortable with the current rate of growth of science and technology. A minority believes the rate of growth is "much too fast" (9 percent) or "a little too fast" (16 percent). A somewhat larger number feels the rate of growth is "a little too slow" (22 percent) or "much too slow" (5 percent). But a plurality (43 percent) says it thinks the current rate of growth of science and technology in the country is "about right" (table 17).

While a majority (54 percent) of the public says it disagrees with the notion: "Unless technological development is restrained, the overall safety of our society will be jeopardized significantly in the next 20 years," there are large differences among subgroups. Among those without high school degrees, 50 percent believe that technological restraints are necessary, while 46 percent believe they are not. There is disagreement among high school graduates (50 to 45 percent) and those

Table 17.—Rate of Growth of Science and Technology

Question (Q4):[a] Do you think that the current rate of growth of science and technology in this country is: much too fast, a little too fast, about right, a little too slow, or much too slow?

		Education			
	Total	Less than high school	High school graduate	Some college	College graduate
	(1,273)[b]	(165)	(458)	(300)	(347)
Much too fast	**9%**	12%	10%	8%	4%
A little too fast	**16**	14	18	16	17
About right	**43**	44	43	43	43
A little too slow	**22**	20	22	24	26
Much too slow	**5**	7	4	5	7
Not sure	**3**	3	4	4	2

[a] The code number of the question in the survey instrument (see app. B.)

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

with some college (55 to 42 percent) that restraint is necessary. Among college graduates, greater than a 3 to 1 ratio (74 to 23 percent) says it rejects the notion that unrestrained technological development will jeopardize the safety of our society (table 16).

The 42 percent minority that feels unrestrained growth in technology will jeopardize the safety of society (table 16) is similar to the 43 percent of the public who believe that the degree of control society has over science and technology should be increased. A plurality, however, believes that the current degree of control should remain as it is (46 percent); and a small minority (8 percent) believes that the current degree of control should be decreased (table 18).

Although a majority of the public still appears to be comfortable with the present degree of regulation and control over technological growth, there is evidence that demand for stricter controls might increase. A National Science Foundation survey also found that the proportion of the public favoring expanded control increased from 28 percent in 1972 to 31 percent in 1976; a decade later this value reached 43 percent in favor of increased control (7). Should the present rate of increase continue, a majority of the public might favor regulation within a decade. The OTA survey reports that at present, a slim majority of Democrats (51 percent) says it already favors increased control. On the other hand, a majority of Republicans believes that the present level of control should remain as is (53 percent) or be decreased (9 percent).

In summary, Americans remain optimistic about the benefits of scientific growth and technological development. They continue to believe that the benefits of scientific innovation outweigh the risks. The public does, however, express a substantial level of concern about technological risks and unrestrained scientific growth, and Americans appear to increasingly favor greater regulation of scientific development.

Table 18.—Degree of Control Over Science and Technology

Question (Q9):[a] Overall, do you think the degree of control that society has over science and technology should be increased, should be decreased, or should remain as it is now?

		Increased	Decreased	Remain as is	Not sure
Total 1986	**(1,273)[b]**	**43%**	**8%**	**46%**	**2%**
1976[c]	(2,108)	31	10	45	14
1972[d]	(2,209)	28	7	48	17
Education:					
Less than high school	(165)	38	11	49	2
High school graduate	(458)	46	8	43	2
Some college	(300)	52	6	41	2
College graduate	(347)	36	7	54	3
Science orientation:					
Observant	(626)	43	9	46	2
Nonobservant	(647)	44	8	46	2
Risk/benefits:					
Benefits	(829)	39	8	51	1
Risks	(316)	53	6	38	2
Voters:	(935)	44	8	46	2
Party affiliation:					
Republican	(435)	37	9	53	2
Independent	(334)	42	9	47	2
Democrat	(441)	51	7	39	3

[a] The code number of the question in the survey instrument (see app. B.)

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

[c] National Science Board, National Science Foundation, *Science Indicators, 1976: An Analysis of the State of U.S. Science and Engineering, and Technology* (Washington, DC: U.S. Government Printing Office, 1977).

[d] National Science Board, National Science Foundation, *Science Indicators, 1972: An Analysis of the State of U.S. Science and Engineering, and Technology* (Washington, DC: U.S. Government Printing Office, 1973).

Chapter 5

Environment and Technology

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Environment and Technology

Agriculture is an important area for the application of biotechnology. Genetic engineering techniques have created several new products—e.g., herbicide-resistant plants and micro-organisms designed to reduce the temperature at which frost can form on a plant—that could become important in agriculture. Because the use of these products requires the deliberate release of the genetically engineered organisms into the environment, concerns about environmental risks have been raised.

These concerns about technology and the environment could significantly influence public opinions about biotechnology and its environmental applications. The environmental movement proved a potent social force during the 1960s and 1970s. In order to assess the role of current public perceptions of technology and environment as a possible factor in biotechnology issues in the 1980s, the OTA survey briefly explored the American public's feelings towards technology and the environment.

DIRECTION OF ENVIRONMENTAL QUALITY

The OTA survey found that the public has mixed feelings about the direction of environmental quality in the United States. A third (32 percent) of the public think the overall quality of the environment is "getting better" compared to 10 years ago. Another 28 percent of the public feel that the quality of the environment is "about the same" today as it was a decade ago. However, nearly 4 out of 10 Americans (39 percent) believe the overall quality of the environment is "getting worse." **Overall, 60 percent of American people believe the quality of the environment has been stable or improved during the past 10 years (table 19). Nevertheless, widespread concern about deteriorating environmental quality persists.**

Table 19.—Direction of Environmental Quality

Question (Q12):[a] Compared to 10 years ago, do you think the overall quality of the environment in the United States is getting better, getting worse, or is about the same?

		Getting better	About the same	Getting worse	Not sure
Total	(1,273)[b]	32%	28%	39%	1%
Age:					
18 to 34	(546)	34	28	37	<1
35 to 49	(343)	37	25	37	1
50 to 64	(252)	26	29	44	1
65 and over	(127)	30	28	40	2
Education:					
Less than high school	(165)	34	30	35	1
High school graduate	(458)	28	30	42	1
Some college	(300)	37	23	39	1
College graduate	(347)	35	25	40	1
Science understanding:					
Very good	(236)	37	28	34	<1
Adequate	(707)	34	27	38	1
Poor	(316)	26	29	45	1
Science orientation:					
Observant	(626)	34	29	36	1
Nonobservant	(647)	30	27	42	1

[a] The code number of the question in the survey instrument (see app. B.)

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

AWARENESS OF ENVIRONMENTAL ISSUES

To examine public awareness of associations between technology and adverse environmental consequences, the survey presented five types of environmental problems that might have a technological origin: radioactive discharge from nuclear powerplants, acid rain, the greenhouse effect, antibiotic-resistant bacteria, and agricultural use of genetically altered microbes.

The vast majority of the public (85 percent) says it has read or heard about radioactive discharges from nuclear powerplants. Yet even after Three Mile Island and Chernobyl, almost one in six Americans admits to having heard or read little about radioactive discharges from nuclear powerplants (table 20).

The issue of acid rain is another now-familiar environmental issue. More than three-fourths of the public (76 percent) say they have heard or read about acid rain. In contrast, fewer than half of American adults (45 percent) say they have heard about the greenhouse effect. Education and science observance are key determinants of this awareness. Nearly twice as many college graduates (69 percent) as high school graduates (35 percent) say they are aware of the greenhouse effect. Similarly, exposure to the issue is found among only a third (34 percent) of science nonobservants compared to better than half of science observants (56 percent). As expected, the separating factors of education and science observance produce far less dramatic differences in awareness of acid rain, a topic that has received wider public exposure (table 20).

Antibiotic-resistant bacteria and agricultural use of genetically engineered microbes are two other environmental issues for which the public reports low exposure. Approximately 4 of 10 Americans (39 percent) say they have heard or read about antibiotic-resistant bacteria. Three of 10 Americans (30 percent) report they have heard or read about the agricultural use of genetically altered microbes (table 20). (Agricultural use of genetically altered microbes, unlike the other four issues, represents a potential environmental problem rather than a current problem.)

Table 20.—Awareness of Some Environmental Issues

Question (Q13a):[a] Have you heard or read much about (READ ITEM)?

		Have heard or read about				
		Radioactive discharge from nuclear powerplants	Acid rain	Greenhouse effect	Antibiotic-resistant bacteria	Agricultural use of genetically altered microbes
Total	**(1,273)**[b]	85%	76%	45%	39%	30%
Education:						
Less than high school	(165)	82	73	38	37	29
High school graduate	(458)	82	70	35	30	24
Some college	(300)	86	81	52	46	33
College graduate	(347)	92	89	69	54	45
Science understanding:						
Very good	(236)	90	81	65	53	46
Adequate	(707)	87	79	48	41	31
Poor	(316)	77	67	27	26	18
Science orientation:						
Observant	(626)	89	82	56	50	40
Nonobservant	(647)	81	71	34	29	21
Rate of growth of science and technology:						
Too fast	(309)	85	72	38	38	28
About right	(549)	84	78	46	38	29
Too slow	(371)	85	79	50	42	34
Voters:	(935)	86	79	48	41	33

[a] The code number of the question in the survey instrument (see app. B.)

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

Education, science orientation, and science understanding are factors in public recognition of lesser known environmental issues. For example, awareness of the issue of genetically altered microbes increases from 21 percent among science nonobservants to 40 percent of science observants (table 20). Although these issues receive higher recognition among the more interested and knowledgeable sections of the populace, **awareness and concern about environmental risks of technology are by no means restricted to science observants. Recognition of and exposure to many environmental issues of science and technology seem to be pervasive in this country.**

CONCERN ABOUT ENVIRONMENTAL ISSUES

Separate from the issue of awareness of environmental issues is concern about the problems. Survey participants were asked how concerned they currently are about each of the five environmental issues of which they were aware. The OTA survey found about half of the public (46 percent) state they are "very concerned" about radioactive discharges from nuclear powerplants. A third (34 percent) report they are "very concerned" about acid rain, but less than half that proportion say they are "very concerned" about antibiotic-resistant bacteria (16 percent), the greenhouse effect (13 percent), or agricultural uses of genetically altered microbes (9 percent) (table 21).

This relatively low level of public concern is accurate in the short term, but misleading for the long term. In large part, the low percentage of individuals who say they are very concerned about some of these issues results from a lack of awareness of the topic. On face value, the low level of concern reported by the public is an accurate gauge of current public sentiment on such issues. However, for long-range planning, public awareness of these problems is likely to grow. This increase could expand the size of the populace who are very concerned with these issues.

To obtain a more detailed picture of the degree of the American public's concern about environmental issues, the proportion of those who report they are very concerned among those who say they have heard or read much about the issue was calculated. The issue of radioactive discharge produces the greatest concern: 54 percent of those who say they have heard about it are "very concerned." The levels of concern about acid rain and antibiotic-resistant bacteria are somewhat lower: 45 and 41 percent of those who report they have heard of them, respectively, are "very concerned." Only 29 and 30 percent, respectively, of those who say they have heard of the greenhouse effect and agricultural use of genetically altered microbes are very concerned.

Table 21.—Level of Concern About Some Environmental Issues[a]

Question (Q13b):[b] How concerned are you at the present time about (ITEM)—very concerned, somewhat concerned, not too concerned, or not at all concerned?

	Very concerned	Somewhat concerned	Not too concerned	Not at all concerned	Never heard	Very concerned and heard of issue
Radioactive discharge from nuclear powerplants	46%	24%	11%	4%	15%	54%
Acid rain	34	28	11	2	24	45
Greenhouse effect	13	20	8	2	55	29
Antibiotic-resistant bacteria	16	16	5	1	61	41
Agricultural use of genetically altered microbes	9	11	6	2	70	30

[a] Number of individuals in sample varies based on who had heard or read about the issue. See table 20.
[b] The code number of the question in the survey instrument (see app. B.)

SOURCE: Office of Technology Assessment, 1987.

ENVIRONMENTAL ACTIVISM

Although there is widespread concern about the quality of the environment and certain environmental consequences of technology, relatively few Americans say they are politically active on environmental issues. Just over 1 in 20 adults (6 percent) reports being active in environmental groups or organizations. This is slightly more than the 4 percent who report being active in consumer groups and organizations and about the same as the percentage active in scientific groups and organizations (6 percent) (table 22).

The survey found greater environmental activism among college graduates (10 percent) than other educational groups (4 to 6 percent). Science observants also have higher environmental activism (7 percent) than do nonobservants (4 percent). And those with a very good understanding of science report that they are more likely (9 percent) than those with only an adequate or poor understanding of science (5 percent each) to be active in environmental groups or organizations. In short, scientific interest and environmental involvement are positively correlated. The survey found that **Americans active in environmental concerns are not particularly opposed to technological development, and are equally likely to feel the current rate of technological growth is too slow (8 percent) as to feel it is too fast (7 percent).**

Table 22.—Profile of Population Active in Environmental Organizations

Question (QF7a):[a] Are you active in any environmental groups or organizations?

		Active
Total	**(1,273)[b]**	**6%**
Age:		
18 to 34	(546)	5
35 to 49	(343)	6
50 to 64	(252)	5
65 and over	(127)	7
Education:		
Less than high school	(165)	4
High school graduate	(458)	5
Some college	(300)	6
College graduate	(347)	10
Science understanding:		
Very good	(236)	9
Adequate	(707)	5
Poor	(316)	5
Science orientation:		
Observant	(626)	7
Nonobservant	(647)	4
Party affiliation:		
Republican	(435)	4
Independent	(334)	6
Democrat	(441)	6
Voters:	(935)	6
Rate of growth of science and technology:		
Too fast	(309)	7
About right	(549)	4
Too slow	(371)	8

[a] The code number of the question in the survey instrument (see app. B.)

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

ENVIRONMENTAL SPOKESPERSONS

The American public expresses mixed feelings about the leaders of the environmental movement. On the one hand, a majority of the American people (57 percent) believes that the leaders of the environmental movement are "out of touch with the public." About one-third (35 percent) say that the leaders of the environmental movement "reflect public feeling" (table 23).

On the other hand, a majority (56 percent) believes that, on the whole, the leaders of the environmental movement are "reasonable in their criticism and demands." Only 33 percent of the public feel environmental leaders are "unreasonable in their criticism and demands." Thus, the public appears to say that while the leadership of the environmental movement is not in touch with public feelings, environmental spokespersons present valid criticisms and reasonable demands (table 24).

This reported ambivalence is not new to the OTA survey. In a 1981 Harris survey, the same mixed picture of public opinions about environmental leadership emerged, and a similar pattern is found in Harris studies of public perceptions of the consumer movement (1). In both cases, the public appears to be happy to have an external voice to present reasonable concerns in a respon-

Table 23.—Opinions About Environmental Leaders

Question (Q14a):[a] On the whole, do you think that the leaders and spokesmen of the environmental movement (READ EACH PAIR OF PHRASES)?

		Reflect public feeling	Are out of touch with the public	Not sure
Total 1986	**(1,273)[b]**	**35%**	**57%**	**7%**
1981[c]	(1,254)	37	54	9
Age:				
18 to 34	(546)	40	54	6
35 to 49	(343)	35	60	5
50 to 64	(252)	31	58	11
65 and over	(127)	28	62	10
Education:				
Less than high school	(165)	30	59	11
High school graduate	(458)	34	61	5
Some college	(300)	39	56	6
College graduate	(347)	42	49	8
Science understanding:				
Very good	(236)	38	48	13
Adequate	(707)	38	58	5
Poor	(316)	30	62	8
Science orientation:				
Observant	(626)	33	58	8
Nonobservant	(647)	37	57	6
Party affiliation:				
Republican	(435)	43	51	6
Independent	(334)	35	58	7
Democrat	(441)	29	62	9
Voters:	(935)	35	58	7

[a] The code number of the question in the survey instrument (see app. B.)

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

[c] Unpublished Harris survey.

SOURCE: Office of Technology Assessment, 1987.

sible fashion—even when the public does not necessarily subscribe to the entire value structure of the advocate.

The better educated have a more positive assessment of both measures of opinions about environmental leaders (reflect public feeling and reasonable in demands). Science orientation and understanding, however, do not have any consistent effect on perceptions of the environmental movement.

TECHNOLOGICAL DEVELOPMENTS AND THE ENVIRONMENT

As stated, OTA investigated public perceptions of the environment to learn whether environmental orientation and concern indicate the possibility of opposition to technological development. OTA found that most Americans (65 percent) believe the overall effect of technological developments on the environment is positive: 14 percent feel that technological innovations have a "very positive" effect, while 51 percent believe technological developments have a "somewhat positive" effect (table 25).

Only a third of the public think that technological developments have a "somewhat negative" (26 percent) or "very negative" (6 percent) effect on the environment. This negative assessment of the effect of technology on the environment appears to be unrelated to age, education, or science orientation. Rather, all population groups express a base level of concern with the environmental consequences of technology across all population groups. Like the earlier concern with the risks of science, the OTA survey does not reveal the

Table 24.—Reasonableness of Demands of Environmental Leaders

Question (Q14b):[a] On the whole, do you think that the leaders and spokesmen of the environmental movement (READ EACH PAIR OF PHRASES)?

		Are reasonable in their criticism and demands	Are unreasonable in their criticism and demands	Not sure
Total 1986	**(1,273)[b]**	**56%**	**33%**	**11%**
1981[c]	(1,254)	52	38	10
Age:				
18 to 34	(546)	63	30	7
35 to 49	(343)	56	37	7
50 to 64	(252)	53	30	17
65 and over	(127)	42	40	18
Education:				
Less than high school	(165)	44	40	16
High school graduate	(458)	58	33	9
Some college	(300)	64	27	9
College graduate	(347)	61	32	7
Science understanding:				
Very good	(236)	55	36	8
Adequate	(707)	58	34	8
Poor	(316)	55	31	15
Science orientation:				
Observant	(626)	57	35	8
Nonobservant	(647)	56	32	13
Party affiliation:				
Republican	(435)	57	34	9
Independent	(334)	55	35	9
Democrat	(441)	57	31	12
Voters:	(935)	55	35	10

[a] The code number of the question in the survey instrument (see app. B.)

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

[c] Unpublished Harris survey.

SOURCE: Office of Technology Assessment, 1987.

Table 25.—Effects of Technology on the Environment

Question (Q11):[a] Overall, what kind of effect do you think technological developments have on the environment—very positive, somewhat positive, somewhat negative, or very negative?

		Very positive	Somewhat positive	Somewhat negative	Very negative
Total	**(1,273)[b]**	**14%**	**51%**	**26%**	**6%**
Age:					
18 to 34	(546)	13	54	26	5
35 to 49	(343)	15	55	22	5
50 to 64	(252)	16	43	27	7
65 and over	(127)	11	45	29	6
Education:					
Less than high school	(165)	15	44	27	8
High school graduate	(458)	14	55	24	4
Some college	(300)	11	53	25	6
College graduate	(347)	13	46	29	6
Science understanding:					
Very good	(236)	19	45	25	7
Adequate	(707)	14	54	23	5
Poor	(316)	9	49	31	5
Science orientation:					
Observant	(626)	18	47	24	7
Nonobservant	(647)	10	54	27	5
Party affiliation:					
Republican	(435)	11	58	24	4
Independent	(334)	14	47	30	7
Democrat	(441)	16	49	25	4
Voters:	(935)	13	51	26	5

[a] The code number of the question in the survey instrument (see app. B.)

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

source of the concern over the effect of technology on the environment.

Interestingly, concern about environmental effects of technology appears to be unrelated to the perceived risk-benefit trade-offs of scientific growth. Those who believe that technology has a negative impact on the environment are about as likely to believe the current rate of technological growth is "too fast" (31 percent), "too slow" (31 percent), or "about right" (33 percent) (table 26).

Similarly, the relationship between the perceived effect of technology on the environment and perceptions of the overall risk-benefit ratio of continued technological innovation is surprisingly weak. Among those who believe the benefits of continued technological innovation will outweigh the risks, 28 percent believe technology has a negative impact on the environment. Only a slightly higher 35 percent of those who believe the benefits of technological innovation "do not outweigh the risks" believe that technology has a negative effect on the environment (table 27).

Thus, the OTA survey does not demonstrate that the perceived impact of technology on the environment is a major component of public perceptions of scientific growth and technological development. In general, the benefits of science appear to outweigh the risks of science in most people's minds. Although not tested directly by the OTA survey, the personal benefits ascribed to science—better health, longer life, easier work, more income—might be more important factors influencing opinions than the less personal consequences of environmental impact.

Table 26.—Comparison of Rate of Technological Growth and Effects of Technology on the Environment

Effects of technology on the environment	*Continued technological innovation* Too fast	 About right	 Too slow
	(309)[a]	(549)	(371)
Very positive	13%	12%	18%
Somewhat positive	52	52	47
Somewhat negative	22	29	27
Very negative	9	4	4
Both	1	2	1
No effect	1	<1	<1
Not sure	2	1	3

[a] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

Table 27.—Comparison of Effects of Technology on the Environment and Weighing the Benefits of Science v. Risks[a]

Effects of technology on the environment	*Continued technological innovation* Benefits outweigh risks	 Benefits do not outweigh risks
Very positive	15%	12%
Somewhat positive	54	47
Somewhat negative	25	26
Very negative	3	9
Both	1	2
No effect	<1	2
Not sure	1	2

[a] Percentages are presented as weighted sample estimates. The unweighted base from which the sampling variance can be calculated is 1,273.

SOURCE: Office of Technology Assessment, 1987.

Chapter 6

Genetic Engineering

Chapter 6

Genetic Engineering

Public perceptions of biotechnology and genetic engineering will be shaped in part by the public's awareness and knowledge of the issues. Prior reports on science information have generally suggested that the vast majority of the public is scientifically illiterate (see ch. 3). Whether or not this is true, an even casual content analysis of newspapers and news magazines clearly reveals that the American people are being exposed to information about biotechnology, biology, and genetics on a frequent basis.

The OTA survey explored the degree to which the public is currently aware of biotechnology and genetic engineering; what the public understands genetic engineering to mean; and the perceived impact of genetic engineering on their lives. According to the survey results, awareness and concern about genetic engineering are not restricted to a small group of scientifically observant persons, rather, the concepts and issues of genetic engineering have diffused widely into the public consciousness. A combination of science interest and media exposure has produced an American public that is aware—if not necessarily sophisticated—about genetic engineering.

AWARENESS OF GENETIC ENGINEERING

The OTA survey found moderate awareness of genetic engineering among the American public. Less than a quarter of the public (24 percent) report they have heard or read "almost nothing" about genetic engineering. A substantial portion (39 percent) reports hearing or reading "relatively little" about genetic engineering. But more than a third of Americans (35 percent) say they have heard "a fair amount" (29 percent) or "a lot" (6 percent) about genetic engineering (table 28).

Those under 50 years old are more likely to state they have heard a lot or a fair amount about genetic engineering (38 to 40 percent) than those 50 years and older (29 to 30 percent). The most dramatic differences in awareness, however, are seen when educational attainment is considered. The proportion of high school graduates who say the have heard at least a fair amount about genetic engineering is 26 percent; but 44 percent of those with some college and 61 percent of college graduates report they have heard or read at least a fair amount about the topic.

Science observance also affects awareness of genetic engineering. Only one-fourth of the nonobservants (24 percent) say they have heard a fair amount about genetic engineering compared to nearly half of the science observants (49 percent). It is interesting, however, that half of science observants report "relatively little" or no exposure to information about genetic engineering, while nearly a quarter of those classified as nonobservant feel they have heard "a fair amount" about it. Thus, awareness of the issue of genetic engineering is apparently not restricted to the scientifically observant sections of the American populace. In fact, 17 percent of those who report they have a poor understanding of science say they have heard or read "a fair amount" about genetic engineering (table 29).

MEANING OF GENETIC ENGINEERING

All the survey respondents were asked to describe, based on what they know or have heard, what is meant by genetic engineering. The responses to this open-ended question indicate that self-reported exposure to information about genetic engineering is a reasonable—if imperfect—guide. Three-quarters (75 percent) of those who say they have heard almost nothing about genetic engineer-

Table 28.—Awareness of Genetic Engineering

Question (Q17a):[a] How much have you heard or read about genetic enginering—a lot, a fair amount, relatively little, or almost nothing?

		A lot	A fair amount	Relatively little	Almost nothing	Not sure
Total	**(1,273)[b]**	**6%**	**29%**	**39%**	**24%**	**1%**
Age:						
18 to 34	(546)	7	31	38	24	<1
35 to 49	(343)	6	34	35	24	<1
50 to 64	(252)	4	26	40	27	2
65 and over	(127)	7	22	46	24	<1
Education:						
Less than high school	(165)	4	22	40	33	<1
High school graduate	(458)	5	21	41	31	2
Some college	(300)	6	38	42	13	<1
College graduate	(347)	12	49	30	8	<1
Science understanding:						
Very good	(236)	15	38	27	18	1
Adequate	(707)	6	34	41	18	1
Poor	(316)	1	16	42	40	1
Science orientation:						
Observant	(626)	10	39	34	16	<1
Nonobservant	(647)	3	21	44	31	1

[a] The code number of the question in the survey instrument (see app. B.)

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

Table 29.—Meaning of Genetic Engineering

Question (Q17b):[a] Based on what you know or have heard, what is meant by genetic engineering?

	Total	A lot/ fair amount	Relatively little	Almost nothing
	(1,273)[b]	(514)	(486)	(257)
Don't know	44%	18%	47%	75%
Altering/manipulating genes	20	29	18	8
Producing improved/superior organisms	7	12	6	2
Crossbreeding/producing hybrids	6	10	6	3
Producing cures for genetic diseases/defects	6	9	6	1
Producing desired/particular characteristics	5	9	4	2
Producing new organisms/ forms of life	4	8	4	1
Producing super race/perfect people	4	4	4	3
Altering/manipulating chromosomes	3	6	3	<1
Altering gene to produce desired/ specific result	3	5	3	<1

[a] The code number of the question in the survey instrument (see app. B.)

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

ing are also unable to explain what is meant by the term. Nearly half (47 percent) of those who say they have heard relatively little about it cannot explain the meaning of genetic engineering. Only 18 percent of those who say they have heard a lot or a fair amount about genetic engineering cannot explain it. Overall, more than half of American adults (56 percent) can provide a meaningful—though not necessarily strictly accurate—explanation of genetic engineering.

Survey respondents commonly describe genetic engineering as "altering or manipulating genes" (20 percent). "Producing improved or superior organisms" is suggested by 7 percent. The classical biological techniques of "crossbreeding and producing hybrids" are identified as genetic engineering by 6 percent of the public—although many scientists would not include these descriptions. Another 6 percent describe genetic engineering as "producing cures for genetic diseases or defects." One in twenty Americans (5 percent) explains genetic engineering in terms of "producing desired or particular characteristics." "Producing new organisms or forms of life" is suggested by 4 percent. For another 4 percent of the public, genetic engineering means "producing a super race or perfect people" (table 29).

With few exceptions, the public's attempts to explain genetic engineering reflect a general, if imperfect, understanding of the concept. Interestingly, the concept of eugenics does not loom large in these explanations. Rather, the half of the adult population who can explain genetic engineering describe it in terms of manipulating genetic material for human gene therapy or providing new and superior organisms. Thus, although not always technically precise, about one-half of the American public has a good general sense of what genetic engineering means.

CONCEPTS IN BIOTECHNOLOGY

Like all disciplines, biotechnology has a unique vocabulary. The OTA survey found the general American public says that many of the basic terms are familiar. It is important to note that survey respondents tend to overestimate their understanding of vocabulary.

Eighty-five percent of the public say they understand the meaning of "gene." Nearly, three-quarters (73 percent) say they understand the meaning of "chromosome." More than two-thirds (69 percent) say they understand the meaning of "cloning."

Although only a few decades ago the term "DNA" was unknown outside research laboratories, the survey found that today half the adult population (52 percent) report they understand its meaning. Sizable minorities of the public also claim they understand the meaning of techniques such as in vitro fertilization (45 percent) and human gene therapy (39 percent). Furthermore, one in seven (14 percent) believes he or she understands the meaning of "monoclonal antibodies," a more rarified concept (table 30).

Table 30.—Understanding Concepts of Biotechnology[a]

Question (Q16a-h):[b] I'd like you to tell me whether you think you understand the meaning of (READ ITEM).

	Yes	No	Not sure
Gene	85%	15%	<1%
Chromosome	73	25	2
Cloning	69	30	1
Genetic engineering	66	32	1
DNA	52	47	1
In vitro fertilization	45	54	1
Human gene therapy	39	59	2
Monoclonal antibodies	14	85	2

[a] Percentages are presented as weighted sample estimates. The unweighted base from which the sampling variance can be calculated is 1,273.

[b] The code number of the question in the survey instrument (see app. B.)

SOURCE: Office of Technology Assessment, 1987.

Two-thirds of the public (66 percent) feel they understand the meaning of genetic engineering, and these persons are much more likely to say they understand the basic meaning of chromosome (83 percent), cloning (79 percent), and DNA (66 percent). About half of those who say they understand genetic engineering report that they understand its application in human gene ther-

Table 31.—Comparison of Understanding the Meaning of Genetic Engineering v. Meaning of Other Concepts of Biotechnology

Question (Q16):[a] I'd like you to tell me whether you think you understand the meaning of (READ ITEM).

	Understand genetic engineering	
	Yes	No
	(906)[b]	(267)
Understand meaning of:		
Genes	91%	74%
Chromosome	83	54
Cloning	79	49
DNA	66	24
In vitro fertilization	54	27
Human gene therapy	49	19
Monoclonal antibodies	20	2

[a] The code number of the question in the survey instrument (see app. B.)

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

apy (49 percent). One in five (20 percent) of those who believe they understand genetic engineering also say they understand the meaning of monoclonal antibodies (table 31). **While these findings do not prove that two-thirds of the public really understand the meaning of genetic engineering, the data indicate that a substantial number of Americans believe they understand the concepts of genetic engineering and biotechnology.**

Understanding the concept of genetic engineering divides the public into two distinct age groups: those under 50 years old and those 50 and over (about 70 to 57 percent.) These two groups report considerably different levels in their understanding of genetic engineering. There is no significant difference in the self-reported understanding of genetic engineering between those 18 to 34 years old (72 percent) and those 35 to 49 years old (70 percent). Similarly, there is no difference in the level of self-reported understanding between those 50 to 64 years old (57 percent) and those 65 and over (57 percent) (table 32).

Self-reported understanding of the topic increases in frequency from 58 percent of high school graduates to 88 percent of college graduates. Science observants (75 percent) are far more likely to report they understand genetic engineering than are nonobservants (59 percent). The best predictor of understanding genetic engineering, however, is the degree of exposure to information

Table 32.—Profile of Population That Understands the Meaning of Genetic Engineering

Question (Q16):[a] I'd like you to tell me whether you think you understand the meaning of genetic engineering.

		Yes	No	Not sure
Total	**(1,273)[b]**	**66%**	**32%**	**1%**
Age:				
18 to 34	(546)	72	28	<1
35 to 49	(343)	70	28	2
50 to 64	(252)	57	40	3
65 and over	(127)	57	42	1
Education:				
Less than high school	(165)	58	40	2
High school graduate	(458)	58	41	1
Some college	(300)	76	23	2
College graduate	(347)	88	10	1
Science orientation:				
Observant	(626)	75	23	2
Nonobservant	(647)	59	40	1
Heard about genetic engineering:				
A lot/fair amount	(514)	93	6	1
Relatively little	(486)	66	32	2
Almost nothing	(257)	29	69	2

[a] The code number of the question in the survey instrument (see app. B.)

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

about it. Nearly all (93 percent) who say they have heard at least a fair amount about genetic engineering feel they understand it, whereas two-thirds (66 percent) of those who say they have heard relatively little about genetic engineering believe they understand it. Less than one-third (29 percent) of those who say they have heard almost nothing about it feel that they understand genetic engineering.

IMPACTS OF GENETIC ENGINEERING

What does the American public believe the impacts of genetic engineering will be? Survey participants were asked whether they thought each of five scientific developments (solar energy, organ transplants, genetic engineering, robots and automation, and nuclear power) will make life better or worse for people like themselves. The generally positive orientation of the American public toward science is reflected in a majority view that all five developments will improve the quality of life. However, the degree of positive reaction to the five innovations varies widely.

At one end of the scale, nearly everyone (92 percent) feels that solar energy will make the quality of life better. In contrast, about half (51 percent) of the public believe that nuclear power will make life better. Opinions on genetic engineering fall between these two: two-thirds of the public (66 percent) say it will make life better for persons like themselves. This perception is more widespread than the belief that the quality of life will improve with robots and automation (60 percent), but less than the belief that organ transplants will improve life (87 percent) (table 33).

The proportion of those who feel that genetic engineering will make life better has remained essentially the same between 1982 (67 percent) (1) and 1986 (66 percent). However, two significant shifts in perceptions of genetic engineering appear to have occurred during that period. First,

Table 33.—Comparison of the Impact of Genetic Engineering on the Quality of Life to Impacts of Other Scientific Innovations

Question (Q10a):[a] Now, let me ask you about some specific developments. From what you know or have heard, do you think (READ ITEM) will make the quality of life a lot better for people such as yourself, somewhat better, somewhat worse, or much worse?

	Effect of genetic engineering on quality of life		
	Total	Better	Worse
	(1,273)[b]	(824)	(291)
Effect on quality of life of:			
Solar energy:			
Better	92%	93%	94%
Worse	4	3	4
Organ transplants:			
Better	87	91	77
Worse	9	6	18
Genetic engineering:			
Better	66	100	
Worse	22		100
Robots and automation:			
Better	60	66	48
Worse	33	28	47
Nuclear power:			
Better	51	57	41
Worse	43	39	57

[a] The code number of the question in the survey instrument (see app. B.)

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

the proportion believing that genetic engineering will make life "a lot better" has declined from 32 percent in 1982 to 18 percent in 1986. Second, the proportion of Americans who think genetic engineering will make life worse ("somewhat worse" or "a lot worse") has increased from 16 percent in 1982 to 22 percent in 1986 (table 34).

Thus, while a substantial majority of Americans still believes that genetic engineering will make life better rather than worse, the OTA survey found that public enthusiasm about the benefits of genetic engineering has declined since 1982.

Table 34.—Population Profile and the Effect of Genetic Engineering on the Quality of Life

Question (Q10):[a] Now, let me ask you about some specific developments. From what you know or have heard, do you think genetic engineering will make the quality of life a lot better for people such as yourself, somewhat better, somewhat worse, or much worse?

		A lot better	Somewhat better	Somewhat worse	Much worse	Not sure	No effect
Total 1986	**(1,273)[b]**	**18%**	**48%**	**13%**	**9%**	**11%**	**2%**
1982[c]	(1,254)	32	35	9	7	17	NA[d]
Education:							
Less than high school	(165)	18	52	10	6	12	3
High school graduate	(458)	18	46	13	9	12	2
Some college	(300)	17	45	17	11	10	1
College graduate	(347)	19	48	13	10	7	3
Science understanding:							
Very good	(236)	32	47	8	4	7	1
Adequate	(707)	16	50	15	9	8	2
Poor	(316)	12	43	12	11	19	3
Heard about genetic engineering:							
A lot/fair amount	(514)	24	50	13	9	3	1
Relatively little	(486)	14	48	13	8	13	3
Almost nothing	(257)	13	45	13	9	17	2

[a] The code number of the question in the survey instrument (see app. B.)

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

[c] Louis Harris & Associates, *The Road After 1984*, 1983.

[d] Not asked.

SOURCE: Office of Technology Assessment, 1987.

TYPES OF ORGANISMS FOR GENETIC MANIPULATION

The concept and techniques of genetic manipulation can be applied to any living organism. However, public acceptance of genetic manipulation could vary considerably with the type of organism manipulated. The survey was designed to determine how much the views of the public might differ in accepting the genetic manipulation of different organisms.

On a scale of 1 to 10 (where 1 is totally unacceptable and 10 is totally acceptable) the public was asked to rank the genetic manipulation in the laboratory of: human cells, animal cells, plant cells, and bacteria. Using this scale, an expected neutral score is 5.5—i.e., a score midway between 1 and 10.

The OTA survey found that the public clearly differentiates between types of organisms in stating their "degree of acceptability" for genetic manipulation. The mean acceptability of genetic manipulation of human cells in the laboratory is 4.5—below the midpoint between totally acceptable and totally unacceptable (table 35). In contrast, the public believes genetic manipulation of animal cells in the laboratory and manipulation of bacteria are more acceptable than human cell manipulation. The average ratings for animal cell and bacteria manipulation are 5.3 and 5.6 respectively—about midway between totally acceptable and totally unacceptable. Finally, genetic manipulation of plant cells receives the high-

Table 35.—Acceptability of Different Organisms for Genetic Manipulation

Question (Q17c):[a] On a scale of 1 to 10 where 1 is totally unacceptable and 10 is totally acceptable, where would you rank genetic manipulation of (READ ITEM)?

		Average acceptability of genetic manipulation of:			
		In laboratory			
		Human cells	Animal cells	Bacteria	Plant cells
Total	**(1,273)[b]**	**4.5[c]**	**5.3**	**5.6**	**6.6**
Science understanding:					
Very good	(236)	5.2	6.1	5.9	7.2
Adequate	(707)	4.5	5.3	5.6	6.6
Poor	(316)	4.1	4.9	5.4	6.2
Heard about genetic engineering:					
A lot/fair amount	(514)	4.9	5.9	6.0	7.2
Relatively little	(486)	4.3	5.2	5.4	6.3
Almost nothing	(257)	4.3	4.7	5.2	6.0
Effects of genetic engineering:					
Better	(824)	5.1	5.8	6.1	6.8
Worse	(291)	2.9	4.1	4.3	5.9
Religious:					
Very	(618)	4.4	5.2	5.5	6.3
Somewhat	(437)	4.5	5.3	5.7	6.8
Not too/not at all	(308)	5.1	5.9	5.8	7.2

[a] The code number of the question in the survey instrument (see app. B.)

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

[c] Mean score.

SOURCE: Office of Technology Assessment, 1987.

est level of public acceptance. The survey group gives genetic manipulation of plants an average rating of 6.6, clearly on the acceptable side of the scale.

Regardless of the type of organism, the average acceptability score for genetic manipulation increases with general understanding of science. Acceptance also increases with the amount heard about genetic engineering. At the same time, the degree of acceptance of genetic manipulation for all types of organisms declines with religiousness.

The effect of religiousness on the acceptance of genetic manipulation is marked, and its impact persists across opinions about all types of organisms. The acceptability rating of human cell manipulation drops from 5.1 for the "not too religious" to 4.4 for the "very religious." Similarly, the acceptability scores given by the "not too religious" and the "very religious" shift from 5.9 to 5.2 for animal cell manipulation; 5.8 to 5.5 for bacteria manipulation; and 7.2 to 6.3 for plant cell manipulation, respectively.

Although the effects of religiousness on acceptance of genetic manipulation is basically constant across organisms, an interesting difference is noted when the sample is separated by perceptions of the effects of genetic engineering. Those who believe genetic engineering will make life worse give a significantly lower rating to human cell manipulation (2.9)—clearly in the unacceptable range—than they do to other forms (4.1 animal cells; 4.3 bacteria; 5.9 plant cells) of genetic engineering. This may indicate that those who worry about the risks of genetic engineering are primarily concerned with its use in and consequences for humans.

DANGERS OF GENETICALLY ENGINEERED PRODUCTS

The OTA survey found that only 19 percent of the public say they have heard of any potential dangers from genetically engineered products. Awareness of potential dangers rises with education, general understanding of science, and how much has been heard about genetic engineering.

Table 36.—Awareness of Dangers of Genetically Engineered Products

Question (Q20a):[a] Have you heard about any potential dangers from genetically engineered products?

		Yes	No	Not sure
Total	(1,273)[b]	19%	80%	1%
Education:				
Less than high school	(165)	16	84	<1
High school graduate	(458)	13	86	1
Some college	(300)	24	73	3
College graduate	(347)	34	65	1
Science understanding:				
Very good	(236)	34	65	1
Adequate	(707)	19	80	1
Poor	(316)	12	87	2
Heard about genetic engineering:				
A lot/fair amount	(514)	30	68	2
Relatively little	(486)	18	82	1
Almost nothing	(257)	7	92	1
Effect of genetic engineering:				
Better	(824)	20	79	1
Worse	(291)	21	77	2

[a] The code number of the question in the survey instrument (see app. B.)

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

Those who believe genetic engineering will make life worse are no more likely to say that have heard of potential dangers from genetically engineered products than those who report they think it will make life better (table 36).

Smaller still is the portion of the public who can specify a potential danger of genetically engineered products. Over one-third (35 percent) of those who say they have heard of potential dangers of genetically engineered products are unable to say what dangers they have heard. Put differently, only 12 percent of the public can cite a specific potential danger they say they have heard associated with genetically engineered products (table 37).

Among those who report they have heard of potential dangers from genetically engineered products, the problem of containment—the difficulty of controlling the product's spread—is most often cited (16 percent). This is followed by concerns about health hazards and side effects (12 percent), and concern about mutations (10 percent). Other potential dangers cited include environmental contamination (7 percent), unforeseen consequences (7 percent), new diseases (6 percent), cancer (6 percent), antibiotic-resistant diseases (3 percent), side effects (3 percent), and dangers to people and animals who consume the product (3 percent) (table 37).

Table 37.—Identification of Specific Dangers Associated With Genetically Engineered Products

Question (Q20b):[a] What potential dangers have you heard of?

	Total
	(285)[b]
Don't know	35%
Difficult to control growth/spread	16
Health hazards/harmful effects	12
Create mutations/monsters	10
Environmental harm/contamination	7
Unforeseen/unintended consequences	7
Create new bacteria/disease	6
Cause cancer	6
Danger to people/animals who consume product	3
Cause side effects	3
Create antibiotic-resistant disease	3
No natural enemies	1
Create chemical warfare	1
All other	16

[a] The code number of the question in the survey instrument (see app. B.)

[b] Percentages are presented as weighted sample estimates. The unweighted sample base (number of individuals who had heard about dangers) is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

Although only 19 percent say they have ever heard of a danger from genetically engineered products, all individuals surveyed were asked how likely they thought it would be that genetically engineered products will represent a serious danger to people or the environment. Half of the public (52 percent) state they think it is at least "somewhat likely" (43 percent "somewhat likely," 9 percent "very likely") that genetically engineered products will represent a serious danger (table 38)—even though just 19 percent of the public have ever heard of a potential danger.

At first glance this contradiction could be construed as a survey artifact. However, it could point to an important consideration in public opinion about science policy. Beliefs about the risks of scientific developments are not necessarily based on factual information, such as having heard of potential dangers of genetic engineering. Note that while self-reported awareness of identifiable, potential dangers increases with education, the perceived likelihood of the danger declines with education (table 36 and table 38). A relatively widespread general sense that a serious danger from genetically engineered products is at least somewhat likely exists in the population, and is independent of education or information about the products (table 38).

The perceived likelihood of danger from genetically engineered products and the general perception of the current rate of technological growth are positively correlated. Among those who say they think the current rate of growth is too fast, 61 percent report they think a serious danger from genetically engineered products is likely. This sense of impending danger declines to 50 percent of those who feel the current growth rate is about right, and drops further to 46 percent of those who believe the current rate is too slow. Thus, the current unease about genetically engineered products could be a background concern with science and technology in general.

Table 38.—Likelihood of Serious Danger From Genetically Engineered Products

Question (Q21):[a] From what you have heard and read, how likely do you think it is that genetically engineered products will represent a serious danger to people or the environment—very likely, somewhat likely, somewhat unlikely, or very unlikely?

		Very likely	Somewhat likely	Somewhat unlikely	Very unlikely	Not sure
Total	**(1,273)[b]**	**9%**	**43%**	**31%**	**11%**	**6%**
Education:						
Less than high school	(165)	15	42	20	16	8
High school graduate	(458)	7	45	32	8	7
Some college	(300)	9	43	34	10	3
College graduate	(347)	5	37	41	11	6
Science understanding:						
Very good	(236)	13	33	30	18	6
Adequate	(707)	8	45	32	11	4
Poor	(316)	9	44	30	6	10
Heard about genetic engineering:						
A lot/fair amount	(514)	10	39	35	14	3
Relatively little	(486)	6	45	33	9	6
Almost nothing	(257)	14	43	23	10	11
Rate of growth:						
Too fast	(309)	14	47	22	11	6
About right	(549)	6	44	36	9	6
Too slow	(371)	10	36	33	15	6

[a] The code number of the question in the survey instrument (see app. B.)

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

Chapter 7

Environmental Applications of Biotechnology

Chapter 7

Environmental Applications of Biotechnology

A number of potential applications of biotechnology in several areas (including agriculture, animal husbandry, and fisheries) require the release of genetically altered organisms into the environment. Researchers and manufacturers have applied for permission to test genetically altered plants or micro-organisms to produce disease-resistant crops, frost-resistant crops, and more effective pesticides. It is already technically feasible to use recombinant DNA techniques to genetically alter farm animals to improve their weight and other characteristics. A number of other environmental uses for genetically altered organisms (e.g., "oil-eating" bacteria to clean oilspills) are also being developed.

Although these applications are produced by the same techniques as those often used in human cell manipulations, it is possible that public opinions about the environmental uses of genetic engineering differ from opinions about human applications of biotechnology (see ch. 6). Moreover, the potential risks of human gene manipulation and environmental applications of genetically altered organisms are quite different. This chapter focuses on public perceptions and concerns about environmental applications and the deliberate release of genetically engineered organisms into the environment.

AGRICULTURAL USES OF GENETIC MANIPULATION

The American public is moderately aware that genetic engineering is used to produce altered plants and animals. Four out of ten Americans (41 percent) report that they have heard about gene splicing or recombinant DNA to produce hybrid plants and animals. This awareness rises with education from 29 percent of those with less than a high school degree to 62 percent of college graduates (table 39).

The public does not appear to be concerned about the morality of genetic engineering of plants and animals. A large majority (68 percent) says creating hybrid plants and animals through direct manipulation of DNA is not morally wrong. The quarter of the population (24 percent) who feel it is morally wrong are distinguished from the rest of the population by lower educational attainment or greater religiousness. However, a

Table 39.—Awareness of Applications of Genetic Engineering

Question (Q18a):[a] Have you heard about using gene splicing or recombinant DNA to produce hybrid plants and animals by direct genetic manipulation?

		Yes	No	Not sure
Total	(1,273)[b]	41%	58%	1%
Education:				
Less than high school	(165)	29	69	2
High school graduate	(458)	34	65	1
Some college	(300)	51	49	<1
College graduate	(347)	62	37	1
Heard about genetic engineering:				
A lot/fair amount	(514)	65	34	<1
Relatively little	(586)	33	65	1
Almost nothing	(257)	16	83	1

[a] The code number of the question in the survey instrument (see app. B.)

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

Table 40.—Morality of Genetic Manipulation of Plants and Animals

Question (Q18b):[a] Do you believe that creating hybrid plants and animals through direct genetic manipulaton of DNA is morally wrong, or not?

		Morally wrong	Not morally wrong	Depends	Not sure
Total	(585)[b]	24%	68%	4%	4%
Education:					
Less than high school	(48)	41	49	2	8
High school graduate	(160)	30	60	7	3
Some college	(156)	14	79	3	4
College graduate	(220)	13	81	3	3
Religious:					
Very	(247)	32	57	6	5
Somewhat	(215)	19	73	4	4
Not too/not at all	(117)	15	83	1	1
Heard about genetic engineering:					
A lot/fair amount	(358)	20	70	4	5
Relatively little	(179)	24	70	3	2
Almost nothing	(42)	42	47	8	3

[a] The code number of the question in the survey instrument (see app. B.)

[b] Percentages are presented as weighted sample estimates. The unweighted sample base (number of individuals who have heard of technique) is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

majority of even the very religious (57 percent) feels it is not morally wrong to use biotechnology techniques to produce hybrid plants and animals (table 40).

Of those who do feel that plant and animal applications of genetic engineering are morally wrong, religious issues do not seem paramount. Only 31 percent of those who say it is morally wrong explain their objections in terms of religious beliefs or God. In contrast, 35 percent object to such applications on the grounds that "people shouldn't tamper with nature." Other concerns that are expressed include: unforeseen or unintended consequences (8 percent) and opposition to scientific experimentation on animals (4 percent). Others expressed fears that monsters will be created (2 percent), or that the techniques will be used on humans (2 percent), or will harm the environment (1 percent). Thus, moral objections to genetic engineering of plants or animals covers a broad range of beliefs, concerns, and fears that go well beyond religious issues (table 41).

Table 41.—Reasons Why Genetic Manipulation of Plants and Animals Is Morally Wrong

Question (Q18c):[a] Why is that [genetic manipulation of plants and animals] morally wrong?

	Total
	(113)[b]
Shouldn't interfere/tamper with nature	35%
Religious beliefs/not what God intended	31
Unforeseen/unintended consequences	8
Acceptable for plants but not animals	7
Against scientific experimentation on animals	4
Would create monsters/freaks/mutants	2
Future use of humans	2
Harmful to environment	1
All other mentions	18
Don't know	7

[a] The code number of the question in the survey instrument (see app. B.)

[b] Percentages are presented as weighted sample estimates. The unweighted sample base (number of individuals who said technique is morally wrong) is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

CLASSICAL BIOLOGICAL TECHNIQUES AND AGRICULTURE

Some proponents argue that the techniques of genetic engineering are simply more efficient methods of producing the same ends as classical biological techniques. Others argue that the direct manipulation of genetic material is intrinsically different from crossbreeding or cross-fertilization. Does the American public also distinguish between these two positions? To test public perceptions of differences in the two approaches, parallel sections dealing with awareness, morality, and risk of the two different technologies were created in the questionnaire. To avoid an order bias in the assessment, a computer randomly assigned the order of the two sections in each interview. Approximately half of those surveyed were asked about classical biological techniques first and the other half about genetic techniques first.

The OTA survey found that the public is more generally aware of the classical techniques of plant and animal manipulation than of recombinant DNA techniques. Three-fourths of the public (76 percent) say they have heard of classical biological techniques such as cross-fertilizing plants and crossbreeding animals to produce hybrids (table 42). This is nearly twice the proportion of Americans who report they have heard of using gene splicing and recombinant DNA for these purposes (41 percent).

Table 42.—Awareness and Opinions About Classical Biological Techniques

Question (Q15a):[a] Have you heard about biological techniques, such as cross-fertilizing plants or crossbreeding animals to produce hybrids?

Question (Q15b): Do you believe that creating hybrid plants and animals by crossbreeding is morally wrong, or not?

	Total (1,273)[b]
Heard of cross-fertilization or crossbreeding:	
Yes	76%
No	24
Not sure	1
Creating hybrid plants and animals by crossbreeding is:	
Morally wrong	26%[c]
Not morally wrong	66
Depends	5
Not sure	3

[a] The code number of the question in the survey instrument (see app. B.)

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

[c] These weighted sample estimates are based on an unweighted sample base of 999 individuals who had heard of cross-fertilizing or crossbreeding.

SOURCE: Office of Technology Assessment, 1987.

Despite the public's different awareness of the two technologies, Americans do not appear to hold different views about the morality of the two approaches. Among those who say they have heard of classical techniques, the majority (66 percent) believes that crossbreeding to create hybrid plants and animals is not morally wrong, essentially identical to the 68 percent who believe gene splicing to create hybrid plants and animals is not morally wrong. A quarter of the public believe it is morally wrong to create hybrids either by classical biological techniques (26 percent) or by gene splicing (24 percent).

A comparison of the perceptions of morality for the two technologies shows a strong degree of internal agreement. Three-fourths of the public who say they have heard of the two techniques give identical ratings to the morality of the two methods. Fifty-nine percent feel that neither technique is "morally wrong." One percent feels that it "depends" in both cases, and 16 percent believe that both methods are "morally wrong." In addition to the 76 percent who do not shift their positions on the morality of the methods, 10 percent shift from a "not sure" or "depends" position to a "not morally wrong" position, or vice versa. This shifting is divided equally across the two methods. The only difference found between moral positions on the classical v. new techniques is that a slightly larger group of people feels that genetic manipulation is wrong, but classical techniques are not wrong (7 percent) compared to those who believe classical techniques are wrong, but genetic techniques are not wrong (4 percent) (table 43). To the extent that there is any moral issue in the public mind concerning the manipulation of plant and animal offspring, it appears that the moral issue lies in the objective (or end, i.e., the fact that manipulation of any kind is occurring), not the means by which it is achieved.

Table 43.—Comparison of Morality of Genetic Manipulation of Plants and Animals With Classical Biological Techniques[a]

Question (Q15b):[b] Do you believe that creating hybrid plants and animals by crossbreeding is morally wrong, or not?
Question (Q18b): Do you believe that creating hybrid plants and animals through direct genetic manipulaton of DNA is morally wrong, or not?

	Genetic manipulation of plants and animals				
	Morally wrong	Depends	Not morally wrong	Not sure	Total
Classical biological manipulation of plants and animals:					
Morally wrong	16%	<1%	4%	<1%	21%
Depends	1	1	3	—	5
Not morally wrong	7	2	59	3	71
Not sure	<1	—	2	<1	3
Total	23	4	69	4	

[a] Percentages are presented as weighted sample estimates. The unweighted sample base is 541 (number of individuals who said they had heard of both techniques).
[b] The code number of the question in the survey instrument (see app. B.)

SOURCE: Office of Technology Assessment, 1987.

OPINIONS ABOUT THE OBJECTIVES OF BIOTECHNOLOGY

To determine whether public acceptance of biotechnological applications is rooted in the end objectives and not the means, the OTA survey investigated how the public views some alternative uses of genetic techniques. The issue of differential risk was avoided by asking survey respondents to assume that none of these applications involved a direct risk to humans; there was no discussion of environmental risk. Hence, the survey responses reflect the willingness of the public to approve different types of applications of genetic engineering when risk to humans is not an issue; only later was risk introduced.

Seven uses of genetic engineering were presented to survey participants in random order. To represent a range of objectives that vary in terms of their extrinsic social utility, the uses range from cures for human genetic disease, to disease-resistant crops, to larger game fish. In each case, respondents were asked:

> If there was no direct risks to humans, would you strongly approve, somewhat approve, somewhat disapprove, or strongly disapprove of genetic manipulation to produce (ITEM)?

The OTA survey found that a clear majority of Americans says it approves all seven applications of genetic engineering in the survey. The rate of public approval of genetic manipulation ("strongly approve" or "somewhat approve" under risk-free conditions) is: 96 percent to produce new treatments for cancer; 91 percent to produce new vaccines; 87 percent to produce cures for human genetic diseases; 87 percent to produce disease-resistant crops; 85 percent to produce frost-resistant crops; 74 percent to produce more productive farm animals; and 66 percent to produce larger game fish. Although the American public overwhelmingly says it approves the use of genetic engineering for each of the seven objectives tested, there is variation in enthusiasm. A majority states it "strongly approves" the use of genetic engineering for new treatments for cancer (75 percent), new vaccines (57 percent), cures for human genetic diseases (54 percent), and disease-resistant crops (53 percent). A plurality says it "strongly approves" genetic engineering for producing frost-resistant crops (48 percent). However, only a minority says it "strongly approves" the use of genetic manipulation for more productive farm animals (37 percent) or larger game fish (25 percent) (table 44).

The survey responses clearly indicate a broad level of public acceptance of the uses of genetic engineering for a wide range of purposes—**when risk to humans is not a factor**. The levels of posi-

Table 44.—Opinions About Applications of Genetic Engineering Under Risk-Free Conditions[a]

Question (Q19):[b] If there was no direct risk to humans, would you strongly approve, somewhat approve, somewhat disapprove, or strongly disapprove of genetic manipulation to produce (READ ITEM)?

	Strongly approve	Somewhat approve	Somewhat disapprove	Strongly disapprove	Not sure
New treatment for cancer	75%	21%	2%	1%	1%
New vaccines	57	34	5	2	3
Cures for human genetic diseases	54	33	6	3	3
Disease-resistant crops	53	34	7	3	4
Frost-resistant crops	48	37	8	4	4
More productive farm animals	37	37	14	9	3
Larger game fish	25	41	17	13	4

[a] Percentages are presented as weighted sample estimates. The unweighted base from which the sampling variance can be calculated is 1,273.
[b] The code number of the question in the survey instrument (see app. B).

SOURCE: Office of Technology Assessment, 1987.

tive response also suggest what kind of social utility scale the public uses to evaluate the objectives of genetic applications. The uses with the most immediate human benefits are at the top of the list. And, within the category of human benefits, those that offer the greatest personal benefit (i.e., cancer treatments and new vaccines) head the roster. Outside of direct human applications, the approval rate of biotechnology drops with the degree of social utility—crop survival appears before farm productivity, which leads recreational uses (i.e., larger game fish).

The implicit scale of public utility illuminated by the survey appears to be founded less on utilitarian philosophy (i.e., the greatest good for the greatest number) than on the immediacy of personal benefit. Consistent with other findings (see ch. 4), the survey reveals that the public expects science and technological developments to bring personal benefits for them and their families.

LIKELIHOOD OF RISKS

The social acceptability of the objectives of biotechnology is one important factor in understanding public perceptions of genetic engineering, and is closely associated with the moral dimension of the issue. Other key dimensions affecting public perceptions of biotechnology are the degree, type, and likelihood of risk that could result from biotechnological applications.

While scientists argue about the specific degrees of risk associated with genetic applications, they seem to generally agree that two distinct types of risk exist. The first type results from the accidental escape of a genetically engineered organism from a laboratory setting. The survey did not examine this type of risk. The second type involves the deliberate release of a genetically engineered organism into the environment. Public perceptions of and reactions to this type of risk were assessed in the OTA survey.

As stated earlier, only 18 percent of the public report that they have heard of any potential dangers from genetically engineered products, and only 12 percent can articulate any type of specific dangers about which they had heard or read. A majority (52 percent) believes, however, that genetically engineered products are at least somewhat likely to represent a serious danger to humans or the environment.

While the public's fears of genetically engineered products are not well articulated, this does not mean they are undifferentiated. To examine the quality of different fears about genetically engineered products, the survey asked respondents to assess the likelihood of genetically engineered organisms in the environment producing each of seven negative outcomes. The seven outcomes were randomly ordered for each respondent to avoid order effects in responses.

Table 45.—Likelihood of Specific Dangers From Use of Genetically Altered Organisms in the Environment[a]

Question (Q22):[b] From what you have heard or read, how likely do you think it is that the use of genetically engineered organisms in the environment will (READ ITEM)—very likely, somewhat likely, somewhat unlikely, very unlikely?

	Very likely	Somewhat likely	Somewhat unlikely	Very unlikely	Not sure
Create antibiotic-resistant diseases	18%	43%	21%	7%	11%
Produce birth defects in humans	18	39	24	10	9
Create herbicide-resistant weeds	15	41	22	11	11
Endanger the food supply	14	38	29	13	7
Mutate into a deadly disease	13	33	30	14	10
Change rainfall patterns	12	30	30	16	12
Increase the rate of plant or animal extinction	11	34	31	15	9

[a] Percentages are presented as weighted sample estimates. The unweighted base from which the sampling variance can be calculated is 1,273.

[b] The code number of the question in the survey instrument (see app. B).

SOURCE: Office of Technology Assessment, 1987.

A majority of the public feels that four of the seven dangers of environmental release are at least "somewhat likely." The dangers from using genetically engineered organisms in the environment perceived most probable are: the creation of antibiotic-resistant diseases (61 percent); the production of birth defects in humans (57 percent); the creation of herbicide-resistant weeds (56 percent); and the endangerment of the food supply (52 percent). In contrast, a minority of the public believes it "somewhat likely" that the environmental release of these organisms will: mutate into a deadly disease (46 percent); change rainfall patterns (42 percent); or increase the rate of plant or animal extinction (45 percent) (table 45).

However, it should be noted that all of the risks surveyed are perceived as "somewhat likely" rather than "very likely." The proportion of the public who believes that any of these dangers will be very likely as a result of environmental release varies from less than one in five persons who think antibiotic-resistant diseases or birth defects (18 percent each) are very likely, to slightly more than one in ten who feel plant or animal extinction is very likely (11 percent). In short, many of the risks listed—particularly those with direct impact on humans—evoke concern from a majority of the public. But there is little perception that the risks are very likely.

Separate from the issue of what kind of risk could occur is the degree of danger posed by the release of different host organisms. The OTA survey measured the perceived likelihood of environmental danger posed by environmental release of genetically engineered plants and animals v. genetically engineered bacteria. The public splits evenly—at 47 percent—on whether the environmental release of genetically altered plants and animals is likely ("very likely" or "somewhat likely") to pose a danger to the environment (table 46). A majority of American people (68 percent), however, believes it is at least "somewhat likely" that genetically altered bacteria could pose a danger to the environment (table 47).

ACCEPTABLE RISK

Assessment of technological risk is thorny for two reasons. First, there is a serious technical problem in estimating the level of risk associated with any new procedure. Second, there is an even more difficult normative decision of setting the acceptable level of risk. This normative decision

Table 46.—Likelihood of Environmental Risk From Genetically Altered Plants and Animals

Question (Q18d):[a] If new plants or animals produced by direct genetic manipulation can reproduce, how likely do you think this is to pose a danger to the environment—very likely, somewhat likely, somewhat unlikely, or very unlikely?

		Very likely	Somewhat likely	Somewhat unlikely	Very unlikely	Not sure
Total	**(585)[b]**	**13%**	**34%**	**32%**	**15%**	**4%**
Education:						
Less than high school	(48)	17	42	19	15	5
High school graduate	(160)	18	34	27	17	4
Some college	(113)	10	33	39	13	6
College graduate	(220)	6	30	43	17	3
Science orientation:						
Observant	(355)	15	33	32	15	4
Nonobservant	(230)	10	37	32	16	5
Heard about genetic engineering:						
A lot/fair amount	(358)	13	35	32	17	2
Relatively little	(179)	9	36	35	12	8
Almost nothing	(42)	31	22	25	17	5
Voters:	(458)	13	33	33	16	5

[a] The code number of the question in the survey instrument (see app. B).

[b] Percentages are presented as weighted sample estimates. The unweighted sample base (individuals who say they have heard of technique) is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

Table 47.—Likelihood of Environmental Risk From Genetically Altered Bacteria

Question (Q18e):[a] Some bacteria have been produced by direct genetic manipulation. If bacteria created by direct genetic manipulation can reproduce themselves, how likely do you think this is to pose a danger to the environment—very likely, somewhat likely, somewhat unlikely, or very unlikely?

		Very likely	Somewhat likely	Somewhat unlikely	Very unlikely	Not sure
Total	**(585)[b]**	**29%**	**39%**	**19%**	**8%**	**5%**
Education:						
Less than high school	(48)	37	25	18	12	6
High school graduate	(160)	35	40	14	8	3
Some college	(113)	25	43	21	6	6
College graduate	(220)	18	46	25	7	4
Science orientation:						
Observant	(355)	29	38	19	9	4
Nonobservant	(230)	28	41	19	7	5
Heard about genetic engineering:						
A lot/fair amount	(358)	26	42	21	8	3
Relatively little	(179)	25	40	20	6	9
Almost nothing	(42)	56	21	9	14	0
Voters:	(458)	29	38	19	8	6

[a] The code number of the question in the survey instrument (see app. B).

[b] Percentages are presented as weighted sample estimates. The unweighted sample base (individuals who say they have heard of technique) is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

is the policymakers' dilemma of deciding what level of risk is acceptable to gain the expected benefits.

Although decisionmakers set the level, public perception of what constitutes acceptable risk is an important component of public opinion about using technological innovation. While the public's estimates of perceived risk often vary widely from actual risk rates (8), the OTA survey explored public perceptions of acceptable risk. Survey participants were asked:

> Suppose that a new genetically engineered organism had been developed which would significantly increase farm production with no direct risk to humans. Would you approve the environmental use of that organism if the risk of losing some local species of plants or fish was (RISK LEVEL)?

The initial risk level specified was 1 in 100. If the respondent did not approve at that risk level, he or she was asked about a more remote risk level. Once a respondent approved of environmental use at any specified risk level, it was assumed that he or she would approve at lower risk levels and so these were not presented. Regardless of the level of risk the respondent considered acceptable, all respondents were asked if they would approve if the risk were "Unknown," as well as "Unknown, but very remote."

The OTA survey found that the public is not risk averse—at least if the risk is local ecological disruption. A majority of the American public (55 percent) says it approves of the environmental use of a genetically engineered organism designed to increase farm production if the risk of some local plant or fish extinction is no more than 1 in 1,000. At risk rates of 1 in 10,000, nearly two-thirds of the public say they approve. And, at risks of 1 in 1 million, three-fourths (74 percent) of the population approve of the environmental use of altered organisms. However, even at remote levels of risk (i.e., 1 in 1 million), nearly a fifth of the population (18 percent) say they do not approve of the environmental application of genetically engineered products (table 48).

Perhaps what is more important than the acceptable level of known risk is the way the public reacts to unknown risk. If the risk is truly unknown, nearly two-thirds (65 percent) of the public say they do not approve of the environmental application. In fact, **more people approve at a high level of known risk, such as 1 in 100 (40 percent) than at an unknown risk level (31 percent).**

The survey also demonstrates that the phrase "unknown, but very remote risk" (which is frequently used to describe risks of environmental impact) does not maximize public approval. Only 45 percent of the public say that they approve of the environmental release of genetically engineered organisms if the risk is unknown, but very remote. When compared to approval rates for known risks, this suggests that the public evaluates an "unknown, but very remote risk" (45 percent) as somewhere between 1 in 100 (40 percent) and 1 in 1,000 (55 percent).

Table 48.—Acceptable Levels of Risk for Environmental Application of Genetically Engineered Organism[a]

Question (Q23):[b] **Suppose that a new genetically engineered organism had been developed which would significantly increase farm production with no direct risk to humans. Would you approve the environmental use of that organism if the risk of losing some local species of plants or fish was (READ ITEM)?[c]**

	Approve	Not approve	Not sure	No answer[d]
Risk level				
Unknown	31%	65%	3%	<1%
1 in 100	40	51	9	0
1 in 1,000	55	37	3	5
1 in 10,000	65	27	3	5
1 in 100,000	71	21	3	5
1 in 1,000,000	74	18	2	5
Unknown, but very remote	45	46	9	5

[a] Percentages are presented as weighted sample estimates. The unweighted base from which the sampling variance can be calculated is 1,273.

[b] The code number of the question in the survey instrument (see app. B.).

[c] Approvals are cumulative. Persons who approved at a risk level were not asked to approve at lower levels of risk.

[d] As a result of a programming error, those who approved at "Unknown" risk level were not asked about specific risk levels. Those omitted were recontacted to complete the risk section, but the Harris firm was unable to obtain responses from 5% of the sample. These are treated as "No Answer."

SOURCE: Office of Technology Assessment, 1987.

ACCEPTANCE OF REMOTE RISKS

Earlier in this chapter, the acceptance—when there was **no direct risk to humans**—of a number of uses of genetically engineered products was examined. Although not entirely realistic in terms of decisionmaking, the analysis permits an assessment of the American public's perceptions of the use of genetically engineered products outside the issue of risk.

To factor in the **environmental risk component** of public perceptions of environmental applications of genetically engineered organisms, the survey investigated the willingness of Americans to approve the environmental use of genetically engineered organisms, if there were **no direct risk to humans, yet very remote risks to the environment**. Under these risk conditions, a majority of the public says it approves of environmental uses of genetically altered organisms for all five of the purposes tested. The majority reports it approves the use of these products to produce: disease-resistant crops (73 percent); bacteria to clean up oilspills (73 percent); and frost-resistant crops (70 percent). Slimmer majorities say they approve the use of these products to produce: more effective pesticides (56 percent) or larger game fish (53 percent)—at least under these risk conditions (table 49).

The OTA survey found that the specification of environmental risk, even if very remote, affects the willingness of the public to approve environmental uses of these products. The approval rate drops measurably from the description without reference to environmental risk to the description with the reference of very remote risk: disease-resistant crops (87 to 73 percent); frost-resistant crops (85 to 70 percent); and larger game fish (66 to 53 percent). The drop in the approval rate is almost identical, 13 to 15 percentage points, across the different types of environmental uses (table 44 and table 49).

Table 49.—Opinions About Environmental Uses of Genetic Engineering Under Remote Risk Conditions[a]

Question (Q24):[b] If there was no direct risk to humans and only very remote risks to the environment, would you approve or disapprove the environmental use of genetically engineered organisms designed to produce (READ ITEM)?

	Approve	Disapprove	Not sure
Disease-resistant crops	73%	23%	4%
Bacteria to clean oilspills	73	23	4
Frost-resistant crops	70	27	3
More effective pesticides	56	40	4
Larger game fish	53	43	4

[a] Percentages are presented as weighted sample estimates. The unweighted base from which the sampling variance can be calculated is 1,273.

[b] The code number of the question in the survey instrument (see app. B).

SOURCE: Office of Technology Assessment, 1987.

Chapter 8

Human Gene Therapy

Chapter 8

Human Gene Therapy

Routine use of gene therapy to treat genetic diseases is more remote than environmental applications of genetically altered organisms. The first successful use of human gene therapy—using genetic engineering to correct a genetic defect—has not yet occurred. Although the technology to correct specific single defects exists in animal systems, it has yet to be demonstrated in humans. Moreover, scientists have imposed regulatory constraints and rigorous review criteria for future testing. Despite these limitations, the potential exists for human gene therapy and genetic diagnostic technologies to create a medical revolution in treatment. In the next decade, gene therapy could be used in a few individuals to treat some fatal diseases that are currently untreatable. A wide variety of diagnostic tools have become available already.

Public perceptions of human applications of genetic manipulation will be affected by a number of factors. First, the benefits of human gene therapy are considerably different than for environmental applications. Second, human genetic manipulation raises issues of morality of a potentially different nature and magnitude than for environmental applications. Third, concern about human applications might focus as much on the acceptability of uses (i.e., therapeutic v. eugenic) as on the morality of the method. This chapter examines public perceptions of and beliefs about human genetic manipulation, as well as public acceptance of different uses of genetic manipulation in humans.

GENETIC DISEASES

The primary beneficiaries of human gene therapy will be persons and their families who have genetic diseases. At present, only a handful of genetic defects are considered potential candidates for human gene therapy. However, as scientific investigation continues to identify the causes of the vast array of single-gene defects, an increasing number of genetic disorders could be treated through genetic therapy.

As part of the inquiry into public perceptions of biotechnology and genetic engineering, OTA surveyed the **self-reported** incidence of genetic disorders in the American population. As noted earlier, the rate of acceptance of the various uses of biotechnology appears to vary with the likelihood of personal benefit. Thus, the demand for genetic applications to human disorders might be a function of the distribution and frequency, or **perceived** frequency, of the disorders in the population.

Over one-third of the American populace (37 percent) say that one or more immediate family members have (or have had) a genetic problem. Nearly one in six families (16 percent) reports a member who has had a potentially fatal genetic disease. One in twenty families (5 percent) self-reports that a family member has been a carrier of a potentially fatal genetic disease. One in twelve families (8 percent) says a family member has a genetic proclivity to serious illness. Finally, 19 percent of Americans self-report they have immediate family members with other inherited health conditions and 8 percent report members with other birth defects. All together, the OTA survey found that 37 percent of adult respondents report they have (or had) one or more immediate family members with one or more genetic problems (table 50). Thus, the survey found a wide potential array of people who might **perceive** they would benefit from human applications of genetic therapy.

The profile of persons who report having family members with genetic problems shows little variation across the subgroups surveyed. The self-reported incidence of these problems does not differ across the three age groups under 65 years of age. The reported frequency is the same in the

Table 50.—Incidence of Genetic Problems in Immediate Family[a]

Question (F15):[b] Has anyone in your immediate family ever (READ ITEM)?	Percent
Had a potentially fatal genetic disease	16
Been a carrier of a potentially fatal genetic disease	5
Had a genetic proclivity to serious illness	8
Had any other inherited health condition	19
Had any other birth defect	8
Net genetic problems	**37**

[a] Percentages are presented as weighted sample estimates. The unweighted base from which the sampling variance can be calculated is 1,273.
[b] The code number of the question in the survey instrument (see app. B).

SOURCE: Office of Technology Assessment, 1987.

central city and the suburbs, and the reported incidence is nearly the same in the East (35 percent), the South (36 percent), and the West (37 percent). The average incidence of genetic problems self-reported in the Midwest (41 percent) is slightly higher than in other regions (table 51).

The frequency of self-reported genetic problems is higher among whites (39 percent) than among blacks (24 percent). The self-reported incidence of genetic disorders in the family increases from 32 percent of those without high school degrees, to 36 percent of high school graduates, to 41 percent of those who have attended college. Finally, women (41 percent) are more likely than men (32 percent) to report genetic defects in the family. Overall, however, the demographic differences are relatively small—resulting in a fairly uniform distribution of self-assessed genetic disorders in the American population.

Table 51.—Demographic Distribution of Self-Reported Genetic Problems

		Any genetic problems	
		Yes	No
Total	**(1,273)[a]**	**37%**	**63%**
Sex:			
Male	(608)	32	68
Female	(665)	41	59
Age:			
18 to 34	(546)	38	62
35 to 49	(343)	38	62
50 to 64	(252)	38	62
65 and over	(127)	32	68
Education:			
Less than high school	(165)	32	68
High school graduate	(458)	36	64
Some college	(300)	41	59
College graduate	(347)	41	59
Income:			
$ 7,500 or less	(90)	35	65
7,501-15,000	(167)	40	60
15,000-25,000	(240)	33	67
25,001-35,000	(288)	36	64
35,001-50,000	(227)	41	59
More than $50,000	(170)	42	58
Race:			
White	(1,096)	39	61
Black	(140)	24	76
Place:			
Central city	(383)	38	62
SMSA[b] remainder	(583)	38	62
NonSMSA	(307)	33	67
Region:			
East	(316)	35	65
Midwest	(310)	41	59
South	(407)	36	64
West	(240)	37	63
Voters:	(935)	40	60

[a] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.
[b] Standard Metropolitan Statistical Area.

SOURCE: Office of Technology Assessment, 1987.

MORALITY OF HUMAN GENE ALTERATION

The OTA survey indicates that Americans say they find human cell manipulation less acceptable —other things being equal—than the alteration of animal cells, plant cells, or bacteria. Does this mean, however, that the public views genetic alteration of human cells and human gene therapy as immoral?

According to the survey, a majority of the American people feels that genetic alteration of human cells is not morally wrong. Respondents were asked:

> Some people believe that genetic alteration of human cells to treat disease is simply another form of medical treatment. Other people believe that changing the genetic makeup of human cells is morally wrong, regardless of the purpose. On balance, do you feel that changing the genetic makeup of human cells is morally wrong, or not?

The majority of Americans (52 percent) says that it is "not morally wrong" to change the makeup of human cells. However, a substantial minority (42 percent) feels it is "morally wrong." Another 6 percent of the public say they are "not sure" whether it is morally wrong (table 52).

Several factors appear to influence concern about the morality of human applications of genetic engineering. The belief that human genetic manipulation is morally wrong drops dramatically with education, from 49 percent of those without high school degrees, to 36 percent of those with some college, to 28 percent of college graduates. Conversely, the sense that human genetic alteration is morally wrong rises with religiousness, from 23 percent of those who are "not too religious" to 52 percent among the "very religious." The perceived morality of human applications of

Table 52.—Morality of Human Cell Manipulation

Question (Q25):[a] Some people believe that genetic alteration of human cells to treat disease is simply another form of medical treatment. Other people believe that changing the genetic makeup of human cells is morally wrong, regardless of the purpose. On balance, do you feel that changing the genetic makeup of human cells is morally wrong, or not?

		Morally wrong	Not morally wrong	Not sure
Total	**(1,273)[b]**	**42%**	**52%**	**6%**
Education:				
Less than high school	(165)	49	43	8
High school graduate	(458)	46	48	6
Some college	(300)	36	59	5
College graduate	(347)	28	66	5
Religious:				
Very	(618)	52	40	8
Somewhat	(437)	35	62	3
Not too/not at all	(208)	23	72	4
Heard about genetic engineering:				
A lot/fair amount	(514)	34	61	5
Relatively little	(486)	43	51	7
Almost nothing	(257)	51	42	7
Effects of genetic engineering:				
Better	(824)	36	60	4
Worse	(291)	63	31	6
Genetic problem in family:				
Yes	(492)	40	56	4
No	(781)	43	50	7

[a] The code number of the question in the survey instrument (see app. B).

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

biotechnology varies directly with the amount of information about genetic engineering. Only a third (34 percent) of those who say they have heard "a fair amount" about genetic engineering think human applications are morally wrong compared to half (51 percent) of those who say they have heard "almost nothing."

The apparent widespread concern over the morality of human applications is potentially misleading. Responses to subsequent survey items discussed in the next section raise questions about the meaning and importance of this moral judgment. The question, however, does help to interpret the earlier finding about public perceptions of the benefits of genetic engineering. As noted earlier, public opinion about the effects of genetic engineering on the quality of life do not vary with the perceived risks. There is a clear relationship, however, between the perceived morality of human genetic alteration and the expected effects of genetic engineering on the quality of life. Sixty percent of those who think human applications are not morally wrong believe that genetic engineering will make life better. Sixty-three percent of those who think human applications are morally wrong believe that genetic engineering will make life worse. This suggests that either the public calculates morality on the basis of expected personal benefit or the perceived effects of technological innovation on the quality of life are strongly affected by the perceived rightness or wrongness of the action. The survey cannot discriminate between these two explanations.

SPECIFIC APPLICATIONS OF HUMAN GENE THERAPY

As noted in chapter 7, the objective of a biotechnology application is probably more important for public acceptance than the technique itself. Consequently, the survey respondents were asked to rate their approval of scientists changing the makeup of human cells for each of six purposes. The purposes ranged from curing fatal genetic diseases to eugenic goals. As in the previous chapter, the survey demonstrates that the acceptance of human genetic manipulation varies dramatically according to the objective. The findings also bring into question the meaning of the earlier survey result that 42 percent of the public believe human gene manipulation is morally wrong.

A large majority of the American public (84 percent) says it approves ("strongly" or "somewhat") changing the makeup of human cells to stop children from inheriting a usually fatal genetic disease. Similarly, 83 percent of the public say they approve the use of human cell manipulation to cure usually fatal genetic diseases. Over three-fourths of Americans state they approve of human genetic alteration to stop children from inheriting nonfatal birth defects (77 percent) or to reduce the risk of developing a fatal disease later in life (77 percent) (table 53). Each of these applications of human gene therapy receives approval both by majorities of those who consider human cell manipulation morally wrong, and by majorities who think it is not morally wrong. This suggests that the question of the morality of technological applications (discussed in the previous section) cannot be validly answered out of context. **A majority of Americans who think human gene manipulation is morally wrong in the abstract approve it when it is used to save lives and heal sick children.** The majority of the public appears to be more concerned with the morality of the intent—the value of the application—rather than the inherent morality of the method.

Only a minority of the public says it approves the use of human genetic manipulation for eugenic rather than therapeutic purposes. Nonetheless, support for nontherapeutic uses of genetic manipulation is high. Forty-four percent of the public report they approve ("strongly" or "somewhat") the use of genetic engineering to improve the intelligence level that children would inherit. An identical proportion (44 percent) says it approves of genetic manipulation to improve the physical characteristics that children would inherit (table 53).

Table 53.—Opinions About Specific Applications of Human Cell Manipulation[a]

Question (Q26):[b] How do you feel about scientists changing the makeup of human cells to (READ ITEM)—would you strongly approve, somewhat approve, somewhat disapprove, or strongly disapprove?

	Strongly approve	Somewhat approve	Somewhat disapprove	Strongly disapprove	Not sure
Stop children from inheriting a usually fatal genetic disease	51%	33%	8%	7%	1%
Cure a usually fatal genetic disease	48	35	7	7	2
Stop children from inheriting a nonfatal birth defect	41	36	12	9	2
Reduce the risk of developing a fatal disease later in life	39	38	12	9	2
Improve the intelligence level that children would inherit	18	26	22	31	2
Improve the physical characteristics that children would inherit	16	28	23	31	3

[a] Percentages are presented as weighted sample estimates. The unweighted base from which the sampling variance can be calculated is 1,273.

[b] The code number of the question in the survey instrument (see app. B).

SOURCE: Office of Technology Assessment, 1987.

Fifty-three percent of the public say they disapprove ("strongly" or "somewhat") of using gene therapy to improve the intelligence level that children would inherit. A majority (54 percent) also registers disapproval of genetic manipulation to improve the physical characteristics that children would inherit. In contrast, only 15 percent of Americans state they disapprove of gene therapy to stop children from inheriting a usually fatal genetic disease. And 14 percent say they disapprove applications of gene therapy that would cure a usually fatal disease (table 53).

Thus, when faced with concrete uses of human genetic manipulation, the public approves of all the therapeutic uses presented. Human gene therapy gets a vote of confidence even from those who consider human genetic applications, in the abstract, morally wrong. Concerns exist, however, among a majority of the public about the morality and utility of eugenic uses of human genetic manipulation.

GERM LINE APPLICATIONS

At present, proposed uses of human gene therapy are restricted to somatic applications—i.e., clinical trials will only be approved to alter cells that do not affect inherited characteristics. The accepted uses of human gene therapy are restricted to correcting genetic instructions that cause genetic diseases in the individual, but not in a way that will affect diseases passed on to offspring. Such germ line applications are considered off limits in current proposals for human gene therapy.

The public was asked what it thought about the acceptability of somatic v. germ line applications of human genetic engineering. Since it was unlikely that much of the public would recognize the terms "somatic" and "germ line," the question was put to survey respondents in the following way:

> Suppose someone had a genetic defect that would cause usually fatal diseases in them and would likely be inherited by their children. Do you think that doctors should be allowed to correct only the gene affecting the disease in the patient, only the gene that would carry the disease to future generations, both genes, or neither gene?

The OTA survey results show that the public does not seem concerned with the somatic v. germ line distinction in human gene therapy—at least as answered by this question. Under the conditions described to them, 62 percent of the American public think doctors should be allowed to correct both the gene affecting the disease in the

Table 54.—Using Germ Line v. Somatic Cells in Human Gene Therapy

Question (Q27):[a] Suppose someone had a genetic defect that would cause usually fatal diseases in them and would likely be inherited by their children. Do you think that doctors should be allowed to correct only the gene affecting the disease in the patient, only the gene that would carry the disease to future generations, both genes, or neither gene?

		Both	Only affecting patient	Offspring	Neither	Not sure
Total	**(1,273)[b]**	**62%**	**8%**	**14%**	**11%**	**5%**
Education:						
Less than high school	(165)	57	11	15	11	5
High school graduate	(458)	60	7	17	12	4
Some college	(300)	69	6	11	9	5
College graduate	(347)	65	9	10	10	5
Religious:						
Very	(618)	56	10	14	14	6
Somewhat	(437)	68	5	15	10	2
Not too/not at all	(208)	68	8	12	5	7
Heard about genetic engineering:						
A lot/fair amount	(514)	65	8	13	10	3
Relatively little	(486)	61	7	17	10	5
Almost nothing	(208)	59	10	11	14	6

[a] The code number of the question in the survey instrument (see app. B).

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

patient and the gene carrying the disease to future generations. Only 8 percent of the public believe doctors should be restricted to somatic applications. In fact, more people feel doctors should be restricted to gene therapy only for germ line applications (14 percent) than somatic applications (8 percent) (table 54). This could be another example of the end objective being more important to the American public than the means, if respondents thought that germ line applications primarily could help future children.

Finally, 11 percent of the adult population of the United States feel that doctors should not be allowed to correct either gene. This is the segment of the population truly opposed to human gene therapy.

GENETIC TESTING

The use of genetic testing for some circumstances is not new, and nine of ten Americans say they approve making genetic testing available through doctors. Survey respondents were asked:

> If there were genetic tests that would tell a person whether they or their children would be likely to have serious or fatal genetic diseases, would you approve or disapprove of making those tests available through a physician?

Making genetic testing available is overwhelmingly supported by the public. Eighty-nine percent of the American populace say they approve of making such tests available, compared to 9 percent who disapprove (table 55).

Additionally, greater than 8 of 10 Americans (83 percent) report they would take a test before having children, if such a test would tell them whether their children would probably inherit a fatal genetic disease (table 56). Religiousness has little effect on willingness to take a genetic test—81 percent of those describing themselves as very religious say they would take such tests.

Americans are less likely to take tests to determine their own proclivity to genetic diseases.

Table 55.—Availability of Genetic Tests From Physicians[a]

Question (Q28a):[b] If there were genetic tests that would tell a person whether they or their children would be likely to have serious or fatal genetic diseases, would you approve or disapprove of making those tests available through a physician?

	Percent
Approve	89
Disapprove	9
Not sure	2

[a] Percentages are presented as weighted sample estimates. The unweighted base from which the sampling variance can be calculated is 1,273.

[b] The code number of the question in the survey instrument (see app. B).

SOURCE: Office of Technology Assessment, 1987.

Nevertheless, two-thirds of the public say they would take a test to determine if they are likely to develop a fatal disease later in life, if such a test becomes widely available. Religiousness does appear to have a minor influence on the likelihood of taking such a test. Sixty-three percent of the "very religious" say they would take such a test if it were available. Seventy-two percent of the "not too" or "not at all" religious report they would use a test (table 56).

Fetal testing might represent the most sensitive type of genetic testing. Nearly 7 of 10 Americans (69 percent), however, say that if genetic diseases could be detected in the early stages of pregnancy they would want such a test. This acceptance of fetal genetic testing is found across all levels of educational attainment, and a majority of the very religious (63 percent) say they would want such a test (table 57).

Table 56.—Comparison of Religiousness and Using Genetic Tests[a]

Question (Q28b):[b] If genetic tests become available that would indicate whether or not a person was likely to develop a fatal disease later in life, would you personally take such a test or not?

Question (Q29):[b] If genetic tests become available that would indicate whether or not it was likely that your children would inherit a fatal genetic disease, would you personally take such a test before having children or not?

		Religious		
	Total	Very	Somewhat	Not too/ Not at all
Likelihood of developing fatal disease later in life:				
Would take test	**66%**	63%	70%	72%
Would not take test	**29**	32	27	24
Not sure	**4**	5	2	4
Likelihood of children inheriting fatal genetic disease:				
Would take test	**83**	81	86	84
Would not take test	**15**	16	12	12
Not sure	**3**	3	2	3

[a] Percentages are presented as weighted sample estimates. The unweighted base from which the sampling variance can be calculated is 1,273.

[b] The code number of the question in the survey instrument (see app. B).

SOURCE: Office of Technology Assessment, 1987.

GENETIC THERAPY

Most Americans say they are prepared to undergo genetic therapy if genetic testing reveals a high risk for a serious genetic disease. Specifically, survey respondents were asked:

> If tests showed that you were likely to get a serious or fatal genetic disease later in life, how willing would you be to undergo therapy to have those genes corrected?

Nearly 8 of 10 Americans (78 percent) say they would be "very willing" or "somewhat willing" to undergo genetic therapy to correct a genetic proclivity to a serious or fatal disease (table 58).

Table 57.—Fetal Testing for Genetic Disease

Question (Q32):[a] Some genetic diseases can be detected in the fetus during the early stages of pregnancy. Would you want such a test during (your/your spouse's) pregnancy or not?

		Want a test	Don't want a test	Not sure
Total	**(1,273)[b]**	**69%**	**27%**	**4%**
Education:				
Less than high school	(165)	70	23	6
High school graduate	(458)	68	28	4
Some college	(300)	66	30	4
College graduate	(347)	71	24	4
Religious:				
Very	(618)	63	31	6
Somewhat	(437)	75	22	3
Not too/not at all	(208)	73	23	3
Heard about genetic engineering:				
A lot/fair amount	(514)	74	22	4
Relatively little	(486)	67	27	4
Almost nothing	(257)	63	32	5
Human cell alteration:				
Morally wrong	(484)	58	36	5
Not wrong	(715)	78	20	3

[a] The code number of the question in the survey instrument (see app. B).

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

Table 58.—Willingness To Undergo Genetic Therapy To Avoid Fatal Disease

Question (Q30):[a] If tests showed that you were likely to get a serious or fatal genetic disease later in life, how willing would you be to undergo therapy to have those genes corrected—very willing, somewhat willing, somewhat unwilling, very unwilling?

		Very willing	Somewhat willing	Somewhat unwilling	Very unwilling	Not sure
Total	**(1,273)[b]**	**35%**	**43%**	**12%**	**9%**	**2%**
Education:						
Less than high school	(165)	42	38	10	9	1
High school graduate	(458)	33	44	13	8	2
Some college	(300)	35	41	11	10	2
College graduate	(347)	31	47	11	9	1
Religious:						
Very	(618)	34	40	12	12	2
Somewhat	(437)	35	47	11	5	1
Not too/not at all	(208)	39	42	13	5	2
Heard about genetic engineering:						
A lot/fair amount	(514)	40	41	9	9	1
Relatively little	(486)	32	45	13	8	3
Almost nothing	(257)	32	43	14	10	2
Human cell alteration:						
Morally wrong	(484)	28	40	17	14	1
Not wrong	(715)	41	45	7	4	2

[a] The code number of the question in the survey instrument (see app. B).

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

An even larger majority (86 percent) says if it had a child with a usually fatal genetic disease, it would be willing ("very" or "somewhat") to have that child undergo genetic therapy if needed; indeed, a majority says it is "very willing" (51 percent). Religiousness has no effect on this opinion. If they had a child with a fatal genetic disease, the "very religious" (51 percent) say they are just as likely to be very willing to have the child undergo genetic therapy as the "somewhat religious" (51 percent) and the "not too religious" (52 percent) (table 59).

The bottom line on public perceptions of human gene therapy is that **almost all Americans—regardless of age, race, education, religiousness, or even moral reservations about genetic engineering—say they approve and would be willing to use these therapies to save lives.**

Table 59.—Willingness To Have Child Undergo Genetic Therapy To Correct Fatal Disease

Question (Q31):[a] If you had a child with a usually fatal genetic disease, how willing would you be to have the child undergo therapy to have those genes corrected—very willing, somewhat willing, somewhat unwilling, very unwilling?

		Very willing	Somewhat willing	Somewhat unwilling	Very unwilling	Not sure
Total	**(1,273)[b]**	**51%**	**35%**	**7%**	**4%**	**3%**
Education:						
Less than high school	(165)	59	30	4	5	2
High school graduate	(458)	50	36	9	3	3
Some college	(300)	47	36	9	6	2
College graduate	(347)	46	38	6	6	4
Religious:						
Very	(618)	51	32	7	6	4
Somewhat	(437)	51	38	7	3	1
Not too/not at all	(208)	52	37	7	2	2
Heard about genetic engineering:						
A lot/fair amount	(514)	52	34	6	5	2
Relatively little	(486)	50	35	8	3	4
Almost nothing	(257)	51	37	5	5	2
Human cell alteration:						
Morally wrong	(484)	44	35	10	8	3
Not wrong	(715)	57	33	5	2	3

[a] The code number of the question in the survey instrument (see app. B).

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

Chapter 9

The Future of Biotechnology

Chapter 9

The Future of Biotechnology

The final issues addressed in this study of public perception of biotechnology are: What should be done? Where do Americans stand on several key questions of government policy concerning biotechnology? Should genetic engineering and biotechnological research proceed? Should government funding of such research be continued? Should field testing of genetically altered organisms in the environment be permitted? Should commercial use of genetically altered organisms be allowed? And, who should decide on questions involving the use of genetically engineered products? This chapter examines the American public's preferences toward the future of genetic engineering.

OPINIONS ABOUT BIOTECHNOLOGY AND REGULATION

The American people have mixed feelings about biotechnology and its regulation. On one hand, a majority (55 percent) says it agrees ("strongly" or "somewhat") that the risks of genetic engineering have been greatly exaggerated. A majority also says it believes that unjustified fears of genetic engineering have seriously impeded the development of valuable new drugs and therapies (58 percent) (table 60).

Yet, while Americans believe the risks and fears of genetic engineering have been exaggerated, the public also expresses concern about them. More than three-fourths of the public (77 percent) say they agree with the statement that "the potential danger from genetically altered cells and microbes is so great that strict regulations are necessary." Forty-three percent report they "agree strongly" with the statement.

It appears that the public recognizes both the unreasonable fears associated with genetic engineering as well as real risks. The unreasonable fears are seen as having delayed significant benefits from this technology. But the public still comes down on the side of strict regulation of the technology because it perceives potential dangers from the innovations.

Table 60.—General Opinions About Biotechnology[a]

Question (Q33):[b] I will now read you a few statements. For each, please tell me whether you agree strongly, agree somewhat, disagree somewhat, or disagree strongly. (READ EACH ITEM.)

	Agree strongly	Agree somewhat	Disagree somewhat	Disagree strongly	Not sure
The potential danger from genetically altered cells and microbes is so great that strict regulations are necessary	43%	34%	14%	6%	3%
The risks of genetic engineering have been greatly exaggerated	15	40	27	10	8
It would be better if we did not know how to genetically alter cells at all	13	20	34	31	2
The unjustified fears of genetic engineering have seriously impeded the development of valuable new drugs and therapies	20	38	26	9	8
We have no business meddling with nature	26	20	31	21	2

[a] Percentages are presented as weighted sample estimates. The unweighted base from which the sampling variance can be calculated is 1,273.
[b] The code number of the question in the survey instrument (see app. B).

SOURCE: Office of Technology Assessment, 1987.

SHOULD THE CLOCK BE TURNED BACK?

Many scientists believe that new developments in science and technology cannot truly be suppressed, and that innovations from biotechnology are here to stay. Nevertheless, it is important to examine how the public feels about this new group of technologies. Would they turn the clock back if they could? That is, what proportion of the public would prefer that humans not meddle with nature at all? It is important to understand the extent of public hostility toward genetic engineering and biotechnology.

The survey respondents were asked whether they agreed or disagreed with the statement: "It would be better if we did not know how to genetically alter cells at all." Nearly two-thirds of the public say they disagree with this notion. About an equal number disagree "strongly" (31 percent) as disagree "somewhat" (34 percent). In contrast, a third (33 percent) of the public report they agree and say they would prefer to turn the clock back. Slightly more than one in eight Americans (13 percent) "agrees strongly" that it would be better if we did not know how to genetically alter cells at all, and another 20 percent say they "agree somewhat" with the proposition.

Who are these people who feel it would be better not to know? The desire not to know is stated by more women (37 percent) than men (28 percent). Those who say they prefer that humans did not know how to genetically alter cells tend to be older—42 percent of those aged 65 and over say they prefer not to know, compared to 24 percent of the 35- to 49-year-old group (table 61).

Education and religiousness appear to have the greatest effect on the preference not to know. Those who say they would prefer that humans not know how to genetically alter cells declines from 43 percent of individuals without a high school diploma, to 34 percent of high school graduates, to 30 percent of those with some college, to 19 percent of college graduates. Conversely, the belief that it would be better not to know increases from 22 percent for the "not too religious," to 27 percent for the "somewhat religious" and 39 percent for the "very religious."

Table 61.—Profile of Population For or Against Genetic Alteration of Cells

Question (Q33):[a] I will now read you a statement. Please tell me whether you agree strongly, agree somewhat, disagree somewhat, or disagree strongly: It would be better if we did not know how to genetically alter cells at all.

		Agree	Disagree
Total	**(1,273)[b]**	**33%**	**65%**
Sex:			
Male	(635)	28	70
Female	(638)	37	61
Age:			
18 to 34	(546)	32	68
35 to 49	(343)	24	76
50 to 64	(252)	38	56
65 and over	(127)	42	54
Education:			
Less than high school	(165)	43	54
High school graduate	(458)	34	65
Some college	(300)	30	69
College graduate	(347)	19	78
Place:			
Central city	(383)	36	64
SMSA[c] remainder	(583)	32	65
NonSMSA	(307)	30	66
Religious:			
Very	(618)	39	58
Somewhat	(437)	27	72
Not too/not at all	(208)	22	76

[a] The code number of the question in the survey instrument (see app. B).

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

[c] Standard Metropolitan Statistical Area.

SOURCE: Office of Technology Assessment, 1987.

A comparison of the biotechnology-specific belief that it would be better not to know how to alter cells with the more general sentiment that "we have no business meddling with nature" indicates that the desire to turn back the clock is not specific to genetic engineering. There is strong agreement in public opinion on the two measures. About a quarter of the public (24 percent) feel that we have no business meddling with nature and that it would be better not to know how to genetically alter cells (table 62). Nearly twice as many (44 percent) say they disagree with both notions. There are relatively few persons who would prefer to turn back the clock on biotechnology and who are not opposed to our meddling

Table 62.—Comparison of Opinions About Genetically Altering Cells and Business Meddling With Nature[a]

We have no business meddling with nature	*It would be better if we did not know how to genetically alter cells*	
	Agree	Disagree
Agree	24%	20%
Disagree	8	44

[a] Percentages are presented as weighted sample estimates. The unweighted base from which the sampling variance can be calculated is 1,273.

SOURCE: Office of Technology Assessment, 1987.

with nature (8 percent). A larger proportion believes we should not meddle with nature, but does not feel it would be better not to know how to alter cells (20 percent). This latter group is interesting because it might represent a group of people who do not see genetic engineering as meddling with nature or people who feel there is no point trying to reverse time and undo technology.

Using these two measures of opinions about science, the OTA survey found that the underlying sentiment against technological development in the public might be estimated as low as 24 percent (agree with both statements) or as high as 52 percent (agree to either statement). Regardless of the extent, it should be noted that both these statements are underlying sentiments, not action statements. It is entirely possible to hold general preferences—in the abstract—that are inconsistent with specific preferences in concrete situations. While that does not mean that general preferences are not important or potentially influential, **this survey consistently found genetic engineering and biotechnology much more popular when the public was queried in specific instances rather than in the abstract.**

GENETIC RESEARCH

The vast majority of the American public believes that research into genetic engineering should be continued. More than 8 of 10 Americans (82 percent) say they support continued research into genetic engineering. Only 13 percent of the public feel that genetic research should be stopped, and another 5 percent report they are not sure whether genetic research should be continued (table 63).

The degree of support for continued research is strongest among college graduates (90 percent) and those who are "not too religious" (90 percent). But genetic research is also supported by solid majorities of other subpopulations. Over three-quarters of the "very religious" (76 percent) think that research into genetic engineering should be continued. A similar proportion (77 percent) of those who think the dangers of genetic engineering are likely, nonetheless says it favors continued genetic research. More than 7 out of 10 persons (71 percent) who think human cell manipulation is morally wrong say they support continued genetic research. And 63 percent of those who feel that it would be better if we did not know how to genetically alter cells say they believe research into genetic engineering should be continued. Clearly, a consensus exists among the American people that continued research into genetic engineering should proceed. This is a bipartisan, as well as a social, consensus with 80 percent of Republicans and 81 percent of Democrats stating support for such research.

At a somewhat broader level, the survey respondents were asked:

> Do you believe that government funding for biologic research should be increased substantially, increased somewhat, remain about the same, decreased somewhat, or decreased substantially?

Despite a period of budget austerity and public concern about budget deficits, there is no popular support for cutting government funding for biologic research. Only 10 percent of the public feel that government funding for biologic research should be decreased ("substantially" or "somewhat"). A substantial proportion (43 percent) thinks that government funding should stay the same. Finally, 40 percent of Americans think that

Table 63.—Opinions About Genetic Research

Question (Q34):[a] Do you think that research into genetic engineering should be continued or should be stopped?

		Continued	Stopped	Not sure
Total	(1,273)[b]	**82%**	**13%**	**5%**
Education:				
Less than high school	(165)	74	17	9
High school graduate	(458)	82	14	4
Some college	(300)	84	11	5
College graduate	(347)	90	6	4
Religious:				
Very	(618)	76	16	8
Somewhat	(437)	88	8	4
Not too/not at all	(208)	90	8	2
Better not to know:				
Agree	(374)	63	29	8
Disagree	(876)	92	4	3
Dangers of genetic engineering:				
Likely	(636)	77	18	6
Unlikely	(558)	90	7	3
Human cell alteration:				
Morally wrong	(484)	71	21	7
Not wrong	(715)	92	6	2
Party affiliation:				
Republican	(435)	80	15	5
Independent	(334)	86	11	3
Democrat	(441)	81	11	7
Voters:	(935)	83	12	5

[a] The code number of the question in the survey instrument (see app. B).

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

government funding for biologic research should be increased ("substantially" or "somewhat") (table 64). Furthermore, partisan disagreement over funding is relatively small—38 percent of Republicans and 45 percent of Democrats say they favor increased government funding for biologic research.

FIELD TESTING OF GENETICALLY ENGINEERED ORGANISMS

Field testing of genetically engineered organisms is one of the most pressing issues of biotechnology facing the public. Some field tests of genetically engineered plants already have been completed. The Environmental Protection Agency (EPA) has approved small-scale field trials for engineered bacteria as a pesticide and "ice-minus" bacteria to protect plants from frost. Other applications for field tests have been submitted to EPA or other Federal agencies for approval. The first small-scale field trials of genetically engineered micro-organisms took place in the United States in April 1987. But what does the public think about such testing?

The OTA survey found overwhelming public support for field testing of genetically altered organisms on an experimental basis. Survey respondents were asked:

> Do you think that environmental applications of genetically altered organisms to increase agricultural productivity or clean up environmental pollutants should be permitted on a small-scale, experimental basis, or not?

Eight of ten Americans (82 percent) think that small-scale field tests of these types of genetically altered organisms should be permitted.

Table 64.—Funding for Biologic Research

Question (Q35):[a] Do you believe that government funding for biologic research should be increased substantially, increased somewhat, remain about the same, decreased somewhat, or decreased substantially?

		Increase			Decrease		
		Substantially	Somewhat	Remain same	Somewhat	Substantially	Not sure
Total	(1,273)[b]	**11%**	**29%**	**43%**	**6%**	**4%**	**7%**
Education:							
Less than high school	(165)	11	29	45	5	3	8
High school graduate	(458)	11	28	44	8	3	6
Some college	(300)	10	32	40	6	7	5
College graduate	(347)	14	31	39	5	4	7
Religious:							
Very	(618)	12	26	43	8	5	6
Somewhat	(437)	9	34	43	5	2	6
Not too/not at all	(208)	11	31	45	4	2	8
Better not to know:							
Agree	(374)	9	21	48	9	8	5
Disagree	(876)	13	34	40	5	2	7
Dangers of genetic engineering:							
Likely	(636)	11	27	43	8	6	4
Unlikely	(558)	13	33	42	5	1	7
Human cell alteration:							
Morally wrong	(484)	8	23	47	10	7	6
Not wrong	(715)	14	35	39	3	2	6
Party affiliation:							
Republican	(435)	10	28	44	7	4	7
Independent	(334)	8	29	43	8	5	7
Democrat	(441)	14	31	41	5	3	5
Voters:	(935)	10	29	44	6	4	7

[a] The code number of the question in the survey instrument (see app. B).

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

Politically, these field tests are supported by 80 percent of Democrats and 85 percent of Republicans (table 65).

Furthermore, like support for genetic research, support for environmental release on an experimental basis is found even among those groups that are less enthusiastic—in the abstract—about genetic engineering. Those who are very religious say they support field tests by a 79 to 15 percent margin. Those who feel that genetic engineering is likely to pose a serious danger to humans or the environment state they support experimental release by a 78 to 18 percent margin. And, those who feel it would be better not to know how to genetically alter cells, nonetheless say they support field testing of genetically altered organisms by a 69 to 25 percent margin. **No identifiable subset of the American population says it widely opposes the environmental release of potentially beneficial organisms on an experimental basis.**

RELEASE IN YOUR COMMUNITY?

The acid test of public reaction to a policy initiative is what people would think if it were done in their community. There are many government activities that the public supports—prisons, waste disposal, drug treatment—but not in their own neighborhood. To put the issue of public opinion about environmental release to a real test, the survey investigated the question in the context of the

Table 65.—Environmental Release on an Experimental Basis

Question (Q36):[a] Do you think that environmental applications of genetically altered organisms to increase agricultural productivity or clean up environmental pollutants should be permitted on a small-scale, experimental basis, or not?

		Yes	No	Not sure
Total	**(1,273)[b]**	**82%**	**13%**	**4%**
Education:				
Less than high school	(165)	77	15	8
High school graduate	(458)	82	15	3
Some college	(300)	86	11	2
College graduate	(347)	88	11	1
Religious:				
Very	(618)	79	15	6
Somewhat	(437)	87	11	3
Not too/not at all	(208)	85	14	1
Better not to know:				
Agree	(374)	69	25	5
Disagree	(876)	89	8	3
Dangers of genetic engineering:				
Likely	(636)	78	18	4
Unlikely	(558)	89	9	2
Human cell alteration:				
Morally wrong	(484)	76	19	4
Not wrong	(715)	88	9	2
Party affiliation:				
Republican	(435)	85	11	3
Independent	(334)	85	12	3
Democrat	(441)	80	15	5
Voters:	(935)	84	12	4

[a] The code number of the question in the survey instrument (see app. B).

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

respondents' own communities. Survey participants were asked:

> Suppose your community was selected as the site to test a genetically altered organism—such as bacteria that protect strawberries from frost—where there was no direct risk to humans and a very remote potential risk to the local environment. Would you be strongly in favor, somewhat in favor, somewhat opposed, very opposed, or really not care if it were used in your community?

The OTA survey found that a majority of the American public (53 percent) says it favors ("strongly" or "somewhat") field testing this type of genetically altered organism in its own community. Another 14 percent of the public say they "don't care." This leaves a third of the public (32 percent) who say they oppose field testing genetically altered organisms in their community under the described conditions of risk and benefit (table 66).

These results, however, do not represent blanket support of environmental release. The situation described in the question involves "no direct risk to humans and a very remote risk to the local environment." While it would have been interesting to test the effects of differential risk levels on the willingness to approve the use of genetically altered organisms in local communities, it was not possible within the constraints of the sample size and survey length. Based on the results presented in chapter 7, it is probably fair to assume that a different level of risk or type of risk would alter public acceptance rates for field testing.

Nevertheless, under the conditions described for a field test involving environmental release, most Americans say they would favor or be indifferent to having it performed in their communities. Those who feel it is better not to know about genetic engineering (38 percent), who feel human

Table 66.—Willingness To Test Genetically Altered Organisms in a Local Community

Question (Q39):[a] Suppose your community was selected as the site to test a genetically altered organism—such as bacteria that protect strawberries from frost—where there was no direct risk to humans and a very remote potential risk to the local environment. Would you be strongly in favor, somewhat in favor, somewhat opposed, very opposed, or really not care if it was used in your community?

		In favor			Opposed		
		Strongly	Somewhat	Don't care	Somewhat	Strongly	Not sure
Total	**(1,273)**[b]	**14%**	**39%**	**14%**	**21%**	**11%**	**2%**
Education:							
Less than high school	(165)	16	36	15	18	13	1
High school graduate	(458)	13	38	14	22	11	1
Some college	(300)	12	40	11	25	10	3
College graduate	(347)	15	43	13	18	10	1
Religious:							
Very	(618)	15	31	12	25	15	1
Somewhat	(437)	14	49	14	15	6	2
Not too/not at all	(208)	11	41	18	19	9	1
Better not to know:							
Agree	(374)	9	29	12	28	21	2
Disagree	(876)	17	43	15	18	6	1
Dangers of genetic engineering:							
Likely	(636)	14	32	13	25	15	2
Unlikely	(558)	15	48	15	15	6	<1
Human cell alteration:							
Morally wrong	(484)	10	30	14	28	18	1
Not wrong	(715)	18	45	14	16	6	1
Party affiliation:							
Republican	(435)	14	42	15	19	8	2
Independent	(334)	14	35	15	20	15	1
Democrat	(441)	15	38	11	23	10	2
Voters:	(935)	14	40	14	21	10	1

[a] The code number of the question in the survey instrument (see app. B).

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

cell manipulation is wrong (40 percent), or who think dangers from genetic engineering are likely (46 percent) are less likely to say they favor field tests in their community. But even among these subsets of the population most opposed to genetic engineering in the abstract, no majority says it opposes field tests even in its own community **as long as it involves no direct risk to humans and only a very remote risk to the local environment.**

LARGE-SCALE ENVIRONMENTAL RELEASE

Although the public overwhelmingly supports small-scale field tests of environmental release, this does not mean they are ready for large-scale commercial uses. This sentiment is presaged in the earlier survey finding that a solid majority of the public felt that the potential dangers of genetic engineering were sufficiently serious to require strict regulation. There is a reasonable inference that small-scale, experimental testing should be conducted under substantial public scrutiny. The issue of large-scale commercial application, however, evokes a different image.

Table 67.—Large-Scale Environmental Release by Commercial Firms

Question (Q37):[a] Do you think that commercial firms should be permitted to apply genetically altered organisms on a large-scale basis, if the risks of environmental danger are judged to be very small, or not?

		Yes	No	Not sure
Total	**(1,273)[b]**	**42%**	**53%**	**5%**
Education:				
Less than high school	(165)	41	51	7
High school graduate	(458)	41	55	4
Some college	(300)	41	55	4
College graduate	(347)	47	48	5
Religious:				
Very	(618)	39	55	6
Somewhat	(437)	44	51	5
Not too/not at all	(208)	48	49	2
Better not to know:				
Agree	(374)	31	63	6
Disagree	(876)	48	48	4
Dangers of genetic engineering:				
Likely	(636)	36	59	4
Unlikely	(558)	50	46	4
Human cell alteration:				
Morally wrong	(484)	33	63	4
Not wrong	(715)	49	45	5
Party affiliation:				
Republican	(435)	48	48	4
Independent	(334)	41	54	5
Democrat	(441)	39	56	6
Voters:	(935)	42	53	5

[a] The code number of the question in the survey instrument (see app. B).

[b] Percentages are presented as weighted sample estimates. The unweighted sample base is presented in parentheses so that the sampling variance for these estimates can be calculated.

SOURCE: Office of Technology Assessment, 1987.

Survey respondents were asked:

> Do you think that commercial firms should be permitted to apply genetically altered organisms on a large-scale basis, if the risks of environmental danger are judged to be very small, or not?

A majority (53 percent) says that commercial firms should not be permitted to make environmental applications under these circumstances (table 67). Of all subgroups considered, only those who believe dangers from genetic engineering are unlikely say they approve large-scale uses by a 50 to 46 percent margin.

Why is there such a difference in public approval of small-scale field testing (82 percent) and large-scale commercial use (42 percent)? Several differences in the two survey questions could contribute to the different reactions. The environmental risk is described as "very remote" in one question and "very small" in the other. One explicitly states that there is no known risk to humans while the other says nothing about human risks. Hence, the stated risks may have been perceived differently.

However, the differences in the stated risk appear to be small. It seems more plausible that the implied risk of reduced control of large-scale application by a commercial firm is the main cause of the limited public approval. The overall survey evidence strongly suggests that while the public favors genetic engineering, it is concerned that the risks be controlled.

Who should decide whether commercial firms are permitted to apply genetically altered organisms on a large-scale basis? The most often cited source for deciding commercial applications is a government agency—preferred by 37 percent of the public. An external scientific body is preferred by 29 percent. Only 13 percent feel that this decision could be left to the company that developed the product (table 68).

Table 68.—Who Should Decide About Large-Scale Environmental Release[a]

Question (Q38):[b] Who should be responsible for deciding whether or not commercial firms should be permitted to apply genetically altered organisms on a large-scale basis—the company that developed the product, an external scientific body, a government agency, an industrial trade association, or other group?

			Party affiliation		
	Total	Voters	Republican	Independent	Democrat
Government agency	**37%**	38%	38%	35%	38%
External scientific body	**29**	31	32	34	25
Company that developed product	**13**	12	12	8	16
Public/voters/taxpayers/community	**5**	4	4	4	5
Industrial trade association	**4**	4	3	4	4
All other mentions	**8**				
Not sure	**5**	5	4	5	5

[a] Percentages are presented as weighted sample estimates. The unweighted base from which the sampling variance can be calculated is 1,273.

[b] The code number of the question in the survey instrument (see app. B).

SOURCE: Office of Technology Assessment, 1987.

CREDIBILITY OF RISK

Next to the perceived value of the outcome, the nature and the degree of risk associated with the product appear to be crucial to public acceptance or rejection of specific applications of genetic engineering. Complete agreement, however, on the nature and degree of risk in the application of new technology is rare. Moreover, in public debates on the appropriateness of technological applications, statements about the degree of risk are made by people with quite different roles and interests in the issue. The public frequently wonders whom to trust in these circumstances. The policymaker, on the other hand, has to worry about both who should be trusted and whom the public believes.

To determine how credible the public finds alternative sources of risk information, survey respondents were asked: "How likely would you be to believe statements about the risk of such a product made by (ITEM)?" Eight different categories of possible sources of information about risk were surveyed. The order in which the categories were presented was randomized.

The public says it is most likely to believe risk statements made by university scientists: 86 percent say they are at least "inclined to believe" statements about risks from university scientists. The OTA survey found that public health officials have more credibility with the public on questions of risk than do Federal agencies. Eighty-two percent of the public say they are "inclined to believe" public health officials, compared to 69 percent who say they are "inclined to believe" Federal agencies. At the same time, the public reports it is more likely to believe Federal agencies (69 percent) than local officials (54 percent). The distinction in the public's belief in Federal v. local governmental officials is also seen on the public interest side. More Americans say they are at least "inclined to believe" environmental groups on statements of risk (71 percent) than unspecified public interest groups (63 percent) (table 69).

Finally, there is a clear distinction in the public's perceived credibility of two other information sources: the company making the product and the news media. While a majority of the public says it is at least inclined to believe risk statements presented by the other sources mentioned, only a minority of the public (45 percent) says it is inclined to believe statements about environmental risk made by the company making the product. Less credibility is given to statements made by the news media (43 percent).

Whom does the public believe when credible sources disagree? The public says that it is at least "inclined to believe" both Federal agencies (69 percent) and environmental groups (71 percent). Since risk assessments from these two sources have

Table 69.—Credibility About Statements of Risk[a]

Question (Q40):[b] How likely would you be to believe statements about the risk of such a product made by (READ ITEM)? Would you definitely believe them, be inclined to believe them, be inclined not to believe them, or definitely not believe them?

	Definitely believe	Inclined to believe	Inclined not to believe	Definitely not believe	Not sure
University scientists	19%	67%	8%	3%	3%
Public health officials	15	67	12	4	2
Environmental groups	10	61	19	6	3
Federal agencies	9	60	22	6	3
Public interest groups	8	55	27	7	3
Local officials	6	48	34	9	3
Company making the product	6	39	37	15	3
News media	4	39	37	16	4

[a] Percentages are presented as weighted sample estimates. The unweighted base from which the sampling variance can be calculated is 1,273.

[b] The code number of the question in the survey instrument (see app. B).

SOURCE: Office of Technology Assessment, 1987.

differed in the past, the survey respondents were asked,

> Suppose a Federal agency reported that the use of a genetically altered organism did not pose a significant risk to your community but a national environmental group said it did pose a significant risk. Would you tend to believe the Federal agency or the national environmental group?

A majority (63 percent) of the public says it would believe the national environmental group—compared to 26 percent that would believe the Federal agency (table 70). This apparent lack of public trust in governmental pronouncements, when contradicted by another credible source, could be a serious stumbling block in future debates over the applications of biotechnology.

Table 70.—Credibility of Federal Government v. Environmental Groups[a]

Question (Q41):[b] Suppose a Federal agency reported that the use of a genetically altered organism did not pose a significant risk to your community, but a national environmental group said it did pose a significant risk. Would you tend to believe the Federal agency or the national environmental group?

Who believed	Percent
Federal agency	26
Environmental group	63
Depends	7
Not sure	4

[a] Percentages are presented as weighted sample estimates. The unweighted base from which the sampling variance can be calculated is 1,273.

[b] The code number of the question in the survey instrument (see app. B).

SOURCE: Office of Technology Assessment, 1987.

Appendixes

Appendix A

Survey Methodology

Selection of the Sample

The data for this survey were collected from 1,273 telephone interviews conducted from October 30 through November 17, 1986. The sample was drawn from the noninstitutionalized civilian adult population of the United States, 18 years of age and older. Households contacted for the survey were selected by a procedure known as random digit dialing (RDD). This procedure ensures the inclusion of individuals with unlisted or not yet listed telephone numbers, as well as those with listed numbers, and thus provides a sample that reflects the total U.S. population.

The initial stage of sample construction required the development of a national-area-probability sample based on the distribution of the adult population of the United States. First, the adult noninstitutionalized population of the country was stratified by region and type of place. For regional stratification the United States was divided into four regions as follows:

- **East:** Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, District of Columbia, and West Virginia;
- **South:** Virginia, North Carolina, South Carolina, Florida, Georgia, Kentucky, Tennessee, Alabama, Mississippi, Arkansas, Louisiana, Texas, and Oklahoma;
- **Midwest:** Ohio, Michigan, Indiana, Illinois, Wisconsin, Minnesota, Iowa, Missouri, Kansas, Nebraska, South Dakota, and North Dakota;
- **West:** Montana, Wyoming, Colorado, New Mexico, Arizona, Utah, Idaho, Nevada, California, Oregon, Washington, Alaska, and Hawaii.

Three categories for size of place were also employed as strata:

- **Central City:** every place defined as a central city by the Bureau of the Census;
- **Standard Metropolitan Statistical Area (SMSA) Remainder:** every place that is not a central city but is within an SMSA as defined by the Bureau of the Census; and
- **NonSMSA:** every town, village, hamlet or identifiable land division that is not included in any of the other categories.

Within each stratum, counties were selected as the primary sampling units. These primary sampling units were selected in proportion to the distribution of the population within the stratum. Operationally, a listing was constructed of the latest estimates of the adult population of every county within each State comprising each region in rank order—$P_{ij}(A_{i80}/P_{i80})$; then a running cumulative total of gross sums was produced. Next, a random number x, which was less than t/n, where t was the adult population of the stratum, was selected. The sample points (n) were then assigned according to where the numbers x, (x + t/n), (x + 2t/n), (x + 3t/n),. . . . .(x + (n − 1)t/n) fell on the running cumulative total of the adult population within that stratum. This procedure yields an appropriate number of primary sampling units (PSUs) drawn proportionately from the stratified sampling frame.

At the next stage of selection, one telephone number for each PSU was randomly selected from Louis Harris & Associates' updated library of telephone directories. As part of the RDD procedures the selected numbers were then altered by dropping the last two digits of the selected number and replacing them with randomly generated number pairs. As many two-digit randomly selected numbers as needed were appended until a working residential number was reached or until an interview was completed. Technically, this method of sampling produces an epsem sample of all published telephone banks, where the sampling fraction is f = n/N for all elements in all strata.

Each eight-digit telephone number (area code and the first five digits) was generated and recorded on a sample card. Interviewers received a group of sample cards (figure 1) plus another card with five two-digit random numbers to be added to the existing partial telephone numbers. The interviewers added one set of random digits to the eight-digit number on the sample card to generate a full telephone number to call.

For example, the first number called in this case would have been (516) 964-82*10*. If the call resulted in a completion, the interviewer moved to the next sample card. Only one completed interview for each sample card was permitted. However, if the outcome of the call was a refusal, screenout, noneligible, terminate, or disconnect, the interviewer retained the same index card but moved to the next random digit ending: (516) 964-82*32*. If the number dialed resulted in a busy signal or a ringing but unanswered phone, the interviewer placed the card to the side. Busy telephones were redialed after 15 minutes. If four such calls did not result in an answered telephone, the interviewer moved to the next random digit ending.

This second stage sampling technique is known as random digit dialing. The use of RDD sampling eliminates the otherwise serious problem of unlisted telephone numbers. Nationwide, approximately 20 per-

Figure 1-1.—Sample Card

Random digits	Number
10	
32	
47	(516) 964-82__
59	
64	

SOURCE: Louis Harris & Associates, 1987.

cent of all phone subscribers have unlisted phones. Moreover, significant variation occurs among demographic groups, with the number of unlisted phones reaching a high of 26 percent in the West, 29 percent in large metropolitan areas, 25 percent among those earning $5,000 to $10,000, and 32 percent among nonwhites. Thus, as directories grow out of date, noninclusion rates in cities like New York and Chicago may exceed 40 percent among some demographic groups. For these reasons, using published phone listings as the universe is inadequate for telephone surveys and inferior to using random digit dialing.

The "youngest male respondent" selection procedure was employed for this survey. A 48 to 52 male to female ratio was controlled for (of both observants and nonobservants) so that the total sample could be reported as a cross section.

These procedures should produce a national representative sample of the adult population of the United States. However, differential response rates by education, sex, race, region, and size of place can produce some sample distortions from population distribution. To correct for such biases, the demographic characteristics of the achieved sample were compared to Census estimates and sample weights were applied to correct for differences. The final weighted sample used in this background paper should yield unbiased estimates of the adult population of the United States.

Sampling Error

It is important to note that survey results are subject to sampling error—i.e., the difference between obtained results and those that would be obtained by studying the entire population. The size of this error varies with the size of the sample and with the percentage of respondents giving a particular answer. Table 71 illustrates the range of error for samples and subsamples of five different sizes and at different percentages of response. This table can be used to determine the approximate sampling errors associated with results presented in the background paper.

These figures account only for sampling error. Survey research is susceptible to other errors as well, such as data handling and interviewer recording. However, the procedures used by Louis Harris & Associates are designed to keep errors of this kind to a minimum (1).

Table 71.—Sample Error (±) at 95 Percent Confidence Level for Samples of Five Different Sizes

Percentage response	*Size of sample* 1,250	1,000	600	400	100
10 (90)	1.7%	1.9%	2.4%	2.9%	5.9%
20 (80)	2.2	2.5	3.2	3.9	7.8
30 (70)	2.5	2.8	3.7	4.5	9.0
40 (60)	2.7	3.0	3.9	4.8	9.6
50 (50)	2.8	3.1	4.0	4.9	9.8

SOURCE: Louis Harris & Associates, 1987.

Appendix B

Survey Questionnaire

LOUIS HARRIS AND ASSOCIATES, INC.
630 Fifth Avenue
New York, NY 10111

FOR OFFICE USE ONLY:

Questionnaire No.: ____________
1-2-3-4-5

Sample Point No. | | | | | |

Study No. 863012
October 27, 1986 Final Version

Interviewer:____Date:____________

Telephone No.:____

Hello, I'm __________________ from Louis Harris and Associates, the national public opinion research firm. We are conducting a national study for the United States Congress (about public attitudes toward science and technology).

1. How much interest do you have in scientific and technological matters -- are you very interested, somewhat interested, rather uninterested, or not interested at all?

Very interested........(09(____-1
Somewhat interested........____-2
Rather uninterested........____-3
Not interested at all......____-4
Not sure...................____-5
Refused/No answer..........____-6

2. How concerned are you about government policy concerning science and technology -- are you very concerned, somewhat concerned, not very concerned or not concerned at all?

Very concerned.......(10(____-1
Somewhat concerned.......____-2
Not very concerned.......____-3
Not at all concerned.....____-4
Not sure.................____-5
Refused/No answer........____-6

3. If you had to rate your own basic understanding of science and technology, would you say it is very good, adequate or poor?

Very good............(11(____-1
Adequate.................____-2
Poor.....................____-3
Not sure.................____-4
Refused/No answer........____-5

(IF "VERY INTERESTED" in Q1 or "VERY CONCERNED" IN Q2 or "VERY GOOD" in Q3) = QUOTA GROUP 1. ELSE = QUOTA GROUP 2.

Science Attentive....(12(____-1
Science Inattentive......____-2

4. Do you think that the current rate of growth of science and technology in this country is: much too fast, a little too fast, about right, a little too slow or much too slow?

Much too fast........(13(____-1
Little too fast..........____-2
About right..............____-3
Little too slow..........____-4
Much too slow............____-5
Not sure.................____-6
Refused/No answer........____-7

5. How much benefit do you expect you and your family to get from developments in science and technology in the next twenty years -- a lot of benefit, some benefit, little benefit, or no benefit.

A lot of benefit.....(14(____-1
Some benefit.............____-2
Little benefit...........____-3
No benefit...............____-4
Not sure.................____-5
Refused/No answer........____-6

6. How much risk to you and your family do you think developments in science and technology will cause in the next twenty years -- a lot of risk, some risk, little risk, or no risk.

A lot of risk.......(15(____-1
Some risk................____-2
Little risk..............____-3
No risk..................____-4
Not sure.................____-5
Refused/No answer........____-6

7. In your opinion, over the next 20 years will the benefits to society resulting from continued technological and scientific innovation outweigh the related risks to society, or not?

Yes, benefits will outweigh risks.....(16(____-1
No, benefits will not outweigh risks......____-2
It depends (vol.)........................____-3
Not sure.................................____-4
Refused/No answer........................____-5

8. Thinking about society as a whole, please tell me whether you tend to agree or disagree with each of the following statements. (READ EACH STATEMENT)

[ROTATE	Agree	Disagree	Not sure	Refused/ No Answer
a. Unless technological development is restrained, the overall safety of our society will be jeopardized significantly in the next 20 years.......................(17(	____-1	____-2	____-3	____-4
b. The risks associated with advanced technology have been exaggerated ....(18(	____-1	____-2	____-3	____-4
c. Society has only perceived the tip of the iceberg with regard to the risks associated with modern technology....................(19(	____-1	____-2	____-3	____-4
d. Most of the risks of new technology that people worry about never really happen.....(20(	____-1	____-2	____-3	____-4

9. Overall, do you think the degree of control that society has over science and technology should be increased, should be decreased, or should remain as it is now?

Increase.....(21(____-1
Decreased........____-2
Remain as it is..____-3
Not sure.........____-4
Refused/No answer____-5

10. Now, let me ask you about some specific developments. From what you know or have heard, do you think (READ ITEM) will make the quality of life a lot better for people such as yourself, somewhat better, somewhat worse or a lot worse?

[ROTATE]		A Lot Better	Somewhat Better	Somewhat Worse	A Lot Worse	No Effect (Vol.)	Not Sure	Refused/ No answer
a. Genetic engineering	(22(	____-1	____-2	____-3	____-4	____-5	____-6	____-7
b. Robots and automation	(23(	____-1	____-2	____-3	____-4	____-5	____-6	____-7
c. Nuclear power	(24(	____-1	____-2	____-3	____-4	____-5	____-6	____-7
d. Solar energy	(25(	____-1	____-2	____-3	____-4	____-5	____-6	____-7
e. Organ transplants	(26(	____-1	____-2	____-3	____-4	____-5	____-6	____-7

11. Overall, what kind of effect do you think technological developments have on the environment -- very positive, somewhat positive, somewhat negative or very negative?

Very positive.....(27(... -1
Somewhat positive.....____-2
Somewhat negative.....____-3
Very negative.........____-4
Both (vol.)...........____-5
No Effect.............____-6
Not sure..............____-7
Refused/No answer.....____-8

12. Compared to ten years ago, do you think the overall quality of the environment in the United States is getting better, getting worse or is about the same?

Getting better..(28(____-1
Getting worse.......____-2
About the same......____-3
Not sure............____-4
Refused/No answer...____-5

13. Have you heard or read much about (READ ITEM)

|ROTATE|	Q. 13a		Q.13b			
	Yes	No	Very Concerned	Somewhat Concerned	Not Too Concerned	Not At All Concerned
a. Acid rain	(29(____-1	____-2	(34(____-1	____-2	____-3	____-4
b. Greenhouse effect	(30(____-1	____-2	(35(____-1	____-2	____-3	____-4
c. Antibiotic resistant bacteria	(31(____-1	____-2	(36(____-1	____-2	____-3	____-4
d. Radioactive discharge from nuclear power plants	(32(____-1	____-2	(37(____-1	____-2	____-3	____-4
e. Agricultural use of genetically altered microbes	(33(____-1	____-2	(38(____-1	____-2	____-3	____-4

13b. FOR EACH YES: How concerned are you at the present time about (READ ITEM) -- very concerned, somewhat concerned, not too concerned, or not at all concerned.

14. On the whole, do you think that the leaders and spokesperson of the environmental movement (READ EACH PAIR OF PHRASES)?

a. Reflect public feeling..(39(____-1
or
Are out of touch with the public...____-2

Not sure..____-3
Refused/No answer...____-4

b. Are reasonable in their criticisms and demands......................(40(____-1
or
Are unreasonable in their criticisms and demands..........................____-2

Not sure..____-3
Refused/no answer...____-4

|RANDOMLY ASSIGN ORDER OF Q15 SERIES AND Q18 SERIES|

15a. Have you heard about biological techniques, such as cross-fertilizing plants or cross-breeding animals to produce hybrids?

Yes...............(41(____-1 (ASK Q15b)

No...................____-2
Not sure.............____-3 } (SKIP TO Q16)
Refused/No answer.....____-4

15b. Do you believe that creating hybrid plants and animals by cross-breeding is morally wrong, or not?

Morally wrong..(42(____-1
Not wrong.........____-2
Depends (Vol.).....____-3
Not sure...........____-4
Refused/No answer..____-5

15c. If the new plant or animal produced by cross-breeding can reproduce itself, how likely do you think this is to pose a danger to the environment -- very likely, somewhat likely, somewhat unlikely or very unlikely?

Very likely..........(43(____-1
Somewhat likely..........____-2
Somewhat unlikely........____-3
Very unlikely............____-4
Not sure.................____-5
Refused/No answer........____-6

16. I'd like you to tell me whether you think you understand the meaning of (READ ITEM)?

|ROTATE|	Yes	No	Not Sure	Refused/ No Answer
a. Gene	(44(____-1	____-2	____-3	____-4
b. Chromosome	(45(____-1	____-2	____-3	____-4
c. DNA	(46(____-1	____-2	____-3	____-4
d. Genetic engineering	(47(____-1	____-2	____-3	____-4
e. Monoclonal antibodies	(48(____-1	____-2	____-3	____-4
f. Cloning	(49(____-1	____-2	____-3	____-4
g. Human gene therapy	(50(____-1	____-2	____-3	____-4
h. In vitro fertilization	(51(____-1	____-2	____-3	____-4

17a. How much have you heard or read about genetic engineering -- a lot, a fair amount, relatively little or almost nothing?

A lot..........(52(____-1
Fair amount........____-2
Relatively little..____-3
Almost nothing.....____-4
Not sure...........____-5
Refused/No answer..____-6

17b. Based on what you know or have heard, what is meant by genetic engineering?

17c. On a scale of 1 to 10 where 1 is totally unacceptable and 10 is totally acceptable, where would you rank genetic manipulation of (READ ITEM)?

|ROTATE| Totally Unacceptable   Totally Acceptable

a. Human cells in
   a laboratory......(53-54(___-1 ___-2 ___-3 ___-4 ___-5 ___-6 ___-7 ___-8 ___-9 ___-0

b. Animal cells in
   a laboratory......(55-56(___-1 ___-2 ___-3 ___-4 ___-5 ___-6 ___-7 ___-8 ___-9 ___-0

c. Plant cells.......(57-58(___-1 ___-2 ___-3 ___-4 ___-5 ___-6 ___-7 ___-8 ___-9 ___-0

d. Bacteria..........(59-60(___-1 ___-2 ___-3 ___-4 ___-5 ___-6 ___-7 ___-8 ___-9 ___-0

18a. Have you heard about using gene splicing or recombinant DNA to produce hybrid plants, and animals by direct genetic manipulation?

Yes...............(61(____-1 (ASK Q18b)

No....................____-2 } (SKIP TO Q19)
Not sure..............____-3 }
Refused/No answer.....____-4 }

18b. Do you believe that creating hybrid plants and animals through direct genetic manipulation of DNA is morally wrong, or not?

Morally wrong..(62(____-1 (ASK Q18c)

Not wrong..........____-2 (SKIP TO Q18d)

Depends (Vol.).....____-3 } (ASK Q18c)
Not sure...........____-4 }
Refused/No answer..____-5 }

18c. Why is that?

____

____

____

18d. If new plants or animals produced by direct genetic manipulation can reproduce, how likely do you think this is to pose a danger to the environment -- very likely, somewhat likely, somewhat unlikely or very unlikely?

Very likely..........(63(____-1
Somewhat likely..........____-2
Somewhat unlikely........____-3
Very unlikely............____-4
Not sure.................____-5
Refused/No answer........____-6

18e. Some bacteria have been produced by direct genetic manipulation. If bacteria created by direct genetic manipulation can reproduce themselves, how likely do you think this is to pose a danger to the environment -- very likely, somewhat likely, somewhat unlikely, very unlikely?

Very likely..........(64(____-1
Somewhat likely..........____-2
Somewhat unlikely........____-3
Very unlikely............____-4
Not sure.................____-5
Refused/No answer........____-6

19. If there was no direct risk to humans, would you strongly approve, somewhat approve, somewhat disapprove or strongly disapprove of genetic manipulation to produce (READ ITEM)?

[ROTATE]	Strongly Approve	Somewhat Approve	Somewhat Disapprove	Strongly Disapprove	Not Sure
a. Frost resistant crops	(65(____-1	____-2	____-3	____-4	____-5
b. Disease resistant crops	(66(____-1	____-2	____-3	____-4	____-5
c. More productive farm animals	(67(____-1	____-2	____-3	____-4	____-5
d. Cures for human genetic diseases	(68(____-1	____-2	____-3	____-4	____-5
e. Larger game fish	(69(____-1	____-2	____-3	____-4	____-5
f. New vaccines	(70(____-1	____-2	____-3	____-4	____-5
g. New treatments for cancer	(71(____-1	____-2	____-3	____-4	____-5

20a. Have you heard about any potential dangers from genetically engineered products?

Yes...............(72(____-1 (ASK Q20b)

No....................____-2
Not sure..............____-3 } (SKIP TO Q21)
Refused/No answer.....____-4

20b. What potential dangers have you heard of?

____

____

____

21. From what you have heard and read, how likely do you think it is that genetically engineered products will represent a serious danger to people or the environment -- very likely, somewhat likely, somewhat unlikely or very unlikely?

Very likely..........(73(____-1
Fairly likely............____-2
Fairly unlikely..........____-3
Very unlikely............____-4
Not sure.................____-5
Refused/No answer........____-6

22. From what you have heard or read, how likely do you think it is that the use of genetically engineered organisms in the environment will (READ ITEM) -- very likely, somewhat likely, somewhat unlikely, very unlikely?

[ROTATE]	Very Likely	Somewhat Likely	Somewhat Unlikely	Very Un-likely	Not Sure	Refusal/ No Answer
a. Increase the rate of plant or animal extinction	(74(____-1	____-2	____-3	____-4	____-5	____-6
b. Change rainfall patterns	(75(____-1	____-2	____-3	____-4	____-5	____-6
c. Create herbicide resistant weeds	(76(____-1	____-2	____-3	____-4	____-5	____-6
d. Create antibiotic resistant diseases	(77(____-1	____-2	____-3	____-4	____-5	____-6
e. Endanger the food supply	(78(____-1	____-2	____-3	____-4	____-5	____-6
f. Produce birth defects in humans	(79(____-1	____-2	____-3	____-4	____-5	____-6
g. Mutate into a deadly disease	(80(____-1	____-2	____-3	____-4	____-5	____-6

23. Suppose that a new genetically engineered organism had been developed which would significantly increase farm production with no direct risk to humans. Would you approve the environmental use of that organism if the risk of losing some local species of plants or fish was (READ ITEM)?

[AFTER FIRST APPROVE IN B-F, SKIP TO G]

Risk		Approve	Not Approve	Not sure	Refused/ No answer
a. Unknown	(08(	____-1	____-2	____-3	
b. 1 in 100	(09(	____-1	____-2	____-3	____-4
c. 1 in 1,000	(10(	____-1	____-2	____-3	____-4
d. 1 in 10,000	(11(	____-1	____-2	____-3	____-4
e. 1 in 100,000	(12(	____-1	____-2	____-3	____-4
f. 1 in 1,000,000	(13(	____-1	____-2	____-3	____-4
g. Unknown, but very remote	(14(	____-1	____-2	____-3	____-4

24. If there was no direct risk to humans and only very remote risks to the environment, would you approve or disapprove the environmental use of genetically engineered organisms designed to produce (READ ITEM)?

[ROTATE]		Approve	Disapprove	Not sure	Refused/ No answer
a. Frost resistant crops	(15(	____-1	____-2	____-3	____-4
b. More effective pesticides	(16(	____-1	____-2	____-3	____-4
c. Bacteria to clean up oil spills	(17(	____-1	____-2	____-3	____-4
d. Disease resistant crops	(18(	____-1	____-2	____-3	____-4
e. Larger game fish	(19(	____-1	____-2	____-3	____-4

|RANDOMLY ASSIGN Q.25 - 32 to follow Q.41 in half of cases |

25. Some people believe that genetic alteration of human cells to treat disease is simply another form of medical treatment. Other people believe that changing the genetic makeup of human cells is morally wrong, regardless of the purpose. On balance, do you feel that changing the genetic makeup of human cells is morally wrong, or not?

Morally wrong.(21(____-1
Not wrong.........____-2
Not sure..........____-3
Refused/No answer.____-4

26. How do you feel about scientists changing the makeup of human cells to (READ ITEM) -- would you strongly approve, somewhat approve, somewhat disapprove or strongly disapprove?

|ROTATE|

		Strongly Approve	Somewhat Approve	Somewhat Disapprove	Strongly Disapprove	Not Sure	Refused/ No Answer
a.	Cure a usually fatal genetic disease	(22(____-1	____-2	____-3	____-4	____-5	____-6
b.	Reduce the risk of developing a fatal disease later in life	(23(____-1	____-2	____-3	____-4	____-5	____-6
c.	Stop children from inheriting a usually fatal genetic disease	(24(____-1	____-2	____-3	____-4	____-5	____-6
d.	Stop children from inheriting a non-fatal birth defect	(25(____-1	____-2	____-3	____-4	____-5	____-6
e.	Improve the physical characteristics that children would inherit	(26(____-1	____-2	____-3	____-4	____-5	____-6
f.	Improve the intelligence level that children would inherit	(27(____-1	____-2	____-3	____-4	____-5	____-6

27. Suppose someone had a genetic defect that would cause usually fatal diseases in them and would likely be inherited by their children. Do you think that doctors should be allowed to correct only the gene affecting the disease in the patient, only the gene that would carry the disease to future generations, both genes or neither gene?

Only affecting the patient.... (28(____-1
Only affecting the offspring.......____-2
Both...............................____-3
Neither............................____-4
Refused/No answer..................____-5

28a. If there were genetic tests that would tell a person whether they or their children would be likely to have serious or fatal genetic diseases, would you approve or disapprove of making those tests available through a physician?

Approve........(29(____-1
Disapprove.........____-2
Not sure...........____-3
Refused/No answer..____-4

28b. If genetic tests become available that would indicate whether or not a person was likely to develop a fatal disease later in life, would you personally take such a test or not?

Would take test.....(30(____-1
Would not take test.....____-2
Not sure................____-3
Refused/No answer.......____-4

29. If genetic tests become available that would indicate whether or not it was likely that your children would inherit a fatal genetic disease, would you personally take such a test before having children or not?

Would take test.....(31(____-1
Would not take test.....____-2
Not sure................____-3
Refused/No answer.......____-4

30. If tests showed that you were likely to get a serious or fatal genetic disease later in life, how willing would you be to undergo therapy to have those genes corrected -- very willing, somewhat willing, somewhat unwilling, very unwilling?

Very willing....(32(____-1
Somewhat willing....____-2
Somewhat unwilling..____-3
Very unwilling......____-4
Not sure............____-5
Refused/No answer...____-6

31. If you had a child with a usually fatal genetic disease, how willing would you be to have the child undergo therapy to have those genes corrected -- very willing, somewhat willing, somewhat unwilling, very unwilling?

Very willing....(33(____-1
Somewhat willing....____-2
Somewhat unwilling..____-3
Very unwilling......____-4
Not sure............____-5
Refused/No answer...____-6

32. Some genetic diseases can be detected in the fetus during the early stages of pregnancy. Would you want such a test during (your/your spouse's) pregnancy or not?

Want a test......(34(____-1
Not want............____2
Not sure............____-3
Refused/No answer....____-4

33. I will now read you a few statements. For each, please tell me whether you agree strongly, agree somewhat, disagree somewhat or disagree strongly. (READ EACH ITEM)

[ROTATE]	Agree Strongly	Agree Somewhat	Disagree Somewhat	Disagree Strongly	Not sure
a. The potential danger from genetically altered cells and microbes is so great that strict regulations are necessary......(35(	____-1	____-2	____-3	____-4	____-5
b. The risks of genetic engineering have been greatly exaggerated..................(36(	____-1	____-2	____-3	____-4	____-5
c. It would be better if we did not know how to genetically alter cells at all......(37(	____-1	____-2	____-3	____-4	____-5
d. The unjustified fears of genetic engineering have seriously impeded the development of valuable new drugs and therapies........(38(	____-1	____-2	____-3	____-4	____-5
e. We have no business meddling with nature...(39(	____-1	____-2	____-3	____-4	____-5

34. Do you think that research into genetic engineering should be continued or should be stopped?

Continued........(40(____-1
Stopped.............____-2
Not sure............____-3
Refused/No answer....____-4

35. Do you believe that government funding for biologic research should be increased substantially, increased somewhat, remain about the same, descreased somewhat, or decreased substantially?

Increased substantially.......(41(____-1
Increased somewhat................____-2
Remain the same...................____-3
Decreased somewhat................____-4
Decreased substantially...........____-5
Not sure..........................____-6
Refused/No answer.................____-7

36. Do you think that environmental applications of genetically altered organisms to increase agricultural productivity or clean up environmental pollutants should be permitted on a small scale, experimental basis, or not?

Yes............(42(____-1
No................____-2
Not sure..........____-3
Refused/no answer..____-4

37. Do you think that commercial firms should be permitted to apply genetically altered organisms on a large scale basis, if the risks of environmental danger are judged to be very small, or not?

Yes............(43(____-1
No................____-2
Not sure..........____-3
Refused/No answer..____-4

38. Who should be responsible for deciding whether or not commercial firms should be permitted to apply genetically altered organisms on a large scale basis -- the company that developed the product, an external scientific body, a government agency, an industrial trade association, or other group?

Company that developed product........(44(____-1
External scientific body..................____-2
Government agency.........................____-3
Industrial trade association..............____-4
Other group (SPECIFY):
____..____-5
Not sure..................................____-6
Refused/no answer.........................____-7

39. Suppose your community was selected as the site to test a genetically altered organism -- such as bacteria that protect strawberries from frost -- where there was no direct risk to humans and a very remote potential risk to the local environment. Would you be strongly in favor, somewhat in favor, somewhat opposed, very opposed, or really not care if it was used in your community?

Strongly in favor.....(45(____-1
Somewhat in favor.........____-2
Somewhat opposed..........____-3
Very opposed..............____-4
Really Not Care...........____-5
Refused/no answer.........____-6

40. How likely would you be to believe statements about the risk of such a product made by (READ ITEM)? Would you definitely believe them, be inclined to believe them, be inclined not to believe them, or definitely not believe them?

[ROTATE]		Definitely Believe	Inclined to Believe	Inclined not to Believe	Definitely Not Believe	Not Sure
a. Federal agencies	(46(	____-1	____-2	____-3	____-4	____-5
b. University scientists	(47(	____-1	____-2	____-3	____-4	____-5
c. Environmental groups	(48(	____-1	____-2	____-3	____-4	____-5
d. Public health officials	(49(	____-1	____-2	____-3	____-4	____-5
e. News media	(50(	____-1	____-2	____-3	____-4	____-5
f. Company making the product	(51(	____-1	____-2	____-3	____-4	____-5
g. Local officials	(52(	____-1	____-2	____-3	____-4	____-5
h. Public interest groups	(53(	____-1	____-2	____-3	____-4	____-5

41. Suppose a federal agency reported that the use of a genetically altered organism did not pose a significant risk to your community but a national environmental group said it did pose a significant risk. Would you tend to believe the federal agency or the national environmental group?

Agency...........(54(____-1
Environmental group..____-2
Depends (vol.).......____-3
Not sure.............____-4
Refused/no answer....____-5

|ASK EVERYONE|

F1. Now, I'd like to ask you a series of questions for statistical purposes. How old are you?

|__|__|__| years of age
(55-56)

Refused/no answer ____-99
Not sure/don't know..____-Y

F2. What is the last year or grade of school you completed?

No formal schooling.......(57(____-1
First through 7th grade.......____-2
8th grade.....................____-3
Some high school..............____-4
High school graduate..........____-5
Some college..................____-6
Four-year college graduate....____-7
Post graduate.................____-8
Not sure/refused..............____-9

F3. Are you presently employed full time, part time, in the military, unemployed, retired and not working, a student, a homemaker, or are you disabled or too ill too work? |MULTIPLE RECORD|

Employed full time....(58(____-1
Employed part time........____-2
In the military...........____-3

Unemployed................____-4
Retired...................____-5
Student...................____-6
Homemaker.................____-7
Disabled/too ill to work..____-8
Other (Vol.)..............____-9
Not sure/refused......(59(____-1

F4. Including yourself, how many people live in this household?

|___|___| persons in household
(60-61)

Not sure/refused......((____-99

F5. Does anyone in your household have a science or technology related job?

Yes...........(62(____-1
No................____-2
Not sure/refused..____-3

F6. How often do you (READ EACH ITEM) -- daily, weekly, monthly, occasionally, hardly ever, or never?

	Daily	Weekly	Monthly	Occasionally	Hardly Ever	Never	Not sure/ Refused
a. Read books or magazines on science and technology.........(63	(___-1	(___-2	(___-3	(___-4	(___-5	(___-6	(___-7
b. Read the science section of a newspaper.............(64	(___-1	(___-2	(___-3	(___-4	(___-5	(___-6	(___-7
c. Discuss issues related to science with someone else.(65	(___-1	(___-2	(___-3	(___-4	(___-5	(___-6	(___-7

F7. Are you active in any (READ ITEM)?

	Yes	No	Not Sure	Refused/ No answer
a. Environmental groups or organizations (66	(____-1	____-2	____-3	____-4
b. Scientific groups or organizations (67	(____-1	____-2	____-3	____-4
c. Consumer groups or organizations (68	(____-1	____-2	____-3	____-4

F8. During the past four years, that is, since this time in 1982, have you (READ EACH ITEM), or not?

		Have Done	Have Not Done	Not sure	No Answer/ Refused
a. Written a letter to your Congressman, U.S. Senator, or an elected official of your local government	(69(	____-1	____-2	____-3	____-4
b. Contributed to a political campaign	(70(	____-1	____-2	____-3	____-4
c. Campaigned or worked actively for the election of a candidate for Congress, for the U.S. Senate, or for President	(71(	____-1	____-2	____-3	____-4
d. Voted on a local school bond issue or referendum	(72(	____-1	____-2	____-3	____-4
e. Voted in a Congressional election	(73(	____-1	____-2	____-3	____-4

F9. Regardless of how you may vote, what do you usually consider yourself -- a Republican, a Democrat, an independent, or what?

Republican....(74(____-1
Democrat..........____-2
Independent.......____-3
Other.............____-4
Not sure/refused..____-5

F10. How would you describe your own personal political philosophy -- conservative, middle-of-the-road, or liberal?

Conservative.......(75(____-1
Middle-of-the-road.....____-2
Liberal................____-3
Depends (vol.).........____-4
Not sure/refused.......____-5

F11. How important is religion in your daily life? Is it very important, somewhat important, not too important or not important at all?

Very important.......(76(____-1
Somewhat important.......____-2
Not too important........____-3
Not important at all.....____-4
Not sure/refused.........____-5

F12. Which of the following income categories best described your total 1985 household income? Was it (READ EACH ITEM)?

$7,500 or less........(77(____-1
$7,501 to $15,000.........____-2
$15,001 to $25,000........____-3
$25,001 to $35,000........____-4
$35,001 to $50,000........____-5
$50,001 or over...........____-6
Not sure/refused..........____-7

F13. Do you consider yourself white, black, oriental, or what?

White..........................(78(____-1 } (ASK QF14)
Black..............................____-2 }

Oriental/Asian or Pacific Islander..____-3 }
American Indian or Alaskan native...____-4 } (SKIP TO QF15)
Not sure/refused...................____-5 }

F14. Are you of Hispanic origin or descent, or not?

Yes, of Hispanic origin.....(79(____-1
No, not of Hispanic origin......____-2
Not sure/refused................____-3

F15. Has anyone in your immediate family ever (READ ITEM)?

	QF15		QF16			
	Yes	No	Respondent	Spouse	Child	Other
a. Had a potentially fatal genetic disease	(80(____-1	____-2	(12(____-1	____-2	____-3	____-4
b. Been a carrier of a potentially fatal genetic disease	(08(____-1	____-2	(13(____-1	____-2	____-3	____-4
c. Had a genetic proclivity to serious illnesses	(09(____-1	____-2	(14(____-1	____-2	____-3	____-4
d. Had any other inherited health condition	(10(____-1	____-2	(15(____-1	____-2	____-3	____-4
e. Had any other birth defect	(11(____-1	____-2	(16(____-1	____-2	____-3	____-4

F16. |IF YES TO F15| Was that you, a spouse, one of your children or someone else? |RECORD ABOVE|

RECORD SEX [DO NOT ASK]:

Male..(17(____-1
Female... ____-2

This completes the interview. Thank you for your help!

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